VII. Predictive Models

This chapter will present the steps taken in constructing the predictive models of archaeological site location for the Charleston Harbor Project. The approach we chose for this purpose was a multivariate statistical analysis known as multiple regression. Multiple regression is an extension of the concepts surrounding simple regression, which endeavors to predict the values of one variable by reference to the values of another. The ideal relationship described by the model is linear and stipulates that for every incremental increase or decrease in a fixed independent variable, there will be a proportional and incremental increase or decrease in a dependent variable. The dependent variable is the variable we wish to predict given known values of the independent variable, commonly referred to as the predictor variable. Multiple regression considers simultaneously the effects of a number of independent variables on a dependent variable. This is a particularly good technique to use when the researcher is presented with complex relationships that cannot be satisfactorily explained by simpler, single-variable models. Certainly this is the case for the problem of predicting archaeological site location since archaeological sites vary in cultural affiliation, function, and time; and we can reasonably expect this variation to be responsive to different variables.

The first section of this chapter will present a brief overview of regression analysis and the special basis for multiple regression. The second section will review correlational relationships among the variables in the data base. The next section will describe the multiple regression models we derived from this analysis and the final section will test the veracity of the models by applying them to surveyed project areas not included in the original data bases that have known site distributions.

Fundamentals of Regression

Regression is a method whereby the relationship between a dependent and an independent variable is expressed as a linear equation. Relationships of this sort require that variables be either ordinal (ie. ranked) or continuous quantitative measurements (ie. weight, length, distance, etc.). The relationship is illustrated by what is known as a scattergram. Cases are plotted on an x-y axis according to the associated values of the two variables for each case. A perfect positive regression is one in which the scatter of points form a line that intercepts the y-axis at 0 and there is an equal increase or decrease in the dependent variable for every increase or decrease in the independent variable. The point at which the regression line intercepts the y-axis is called the *Intercept*. The line would extend in a 45° angle outward and bisect the area of the x-y axis in a perfect regression (Figure 23). The angle or relative steepness of the line is referred to as the *Slope*. These two measures are expressed as coefficients in regression equations and form the basis for predicting values of the dependent variable. The regression equation takes the following form: $y = a + bx$, where y is the dependent variable, a is the intercept coefficient, also known as the constant, b is the *slope coefficient*, and x is the value of the independent variable.

It is rare, however, to find real world situations in which the relationship between two variables is a perfect linear regression. Instead, the scatter of points is often curved or non-linear, the slope is flatter or steeper than a 45° angle, and the intercept does not run through the 0 point of the axis. In these cases the intercept and slope are calculated as linear relationships and the deviations (ie. residuals) of the points in the scattergram around this theoretical regression line are summed to produce a measurement of the standard error (*e*). The square root of the standard error is the standard deviation of the relationship. This statistic can be plotted as a band on either side of the regression line and contains 67 percent of the cases in the regressed sample. Strong regressions will characteristically have small standard errors, while poor ones will have large errors.

A statistic that measures the success of a regression is called the *coefficient of determination*, or R^2. This coefficient represents the fraction of the variability in the dependent variable that is explained or accounted for by the independent variable. Thus, an R^2 value of .76 would indicate that 76 percent of the variability in the dependent variable is explained by the independent variable. R^2 is expressed as values between 0 and 1. A value of 0 means that the independent (x) variable is not of use in predicting the dependent variable (y), while a value of 1 indicates a perfect linear prediction of y by x.

Multiple Regression extends the principles of the simple linear regression model to include more than one predictor variable. The effects of each predictor variable are considered to be additive in accounting for the variability in y. The equation takes the following form for p predictors: $y = a_0 + b_1 x_1 + b_2 x_2 + \ldots + b_p x_p$. Similarities to the simple regression equation are readily identifiable; a_0 is *the intercept coefficient* or constant and the remaining complex expressions represent the set of independent variables and their associated *slope coefficients*. The predictors are straight-forwardly summed and contain no other functions, hence the term @linear? equation is applied to this model. An important detail to appreciate with multiple regression, however, is that each slope coefficient is calculated after the linear effects of the other variables are accounted for in the equation. Thus, the relative contribution of a particular independent variable in explaining a dependent variable will change with changes in the composition of the set of independent variables used in the equation. R^2 is calculated as a measure of the success of a multiple regression equation as well. For those desiring additional information concerning this topic, excellent discussions of regression analysis can be consulted in Blalock (1972:361-460) and Ott (1984:391-444).

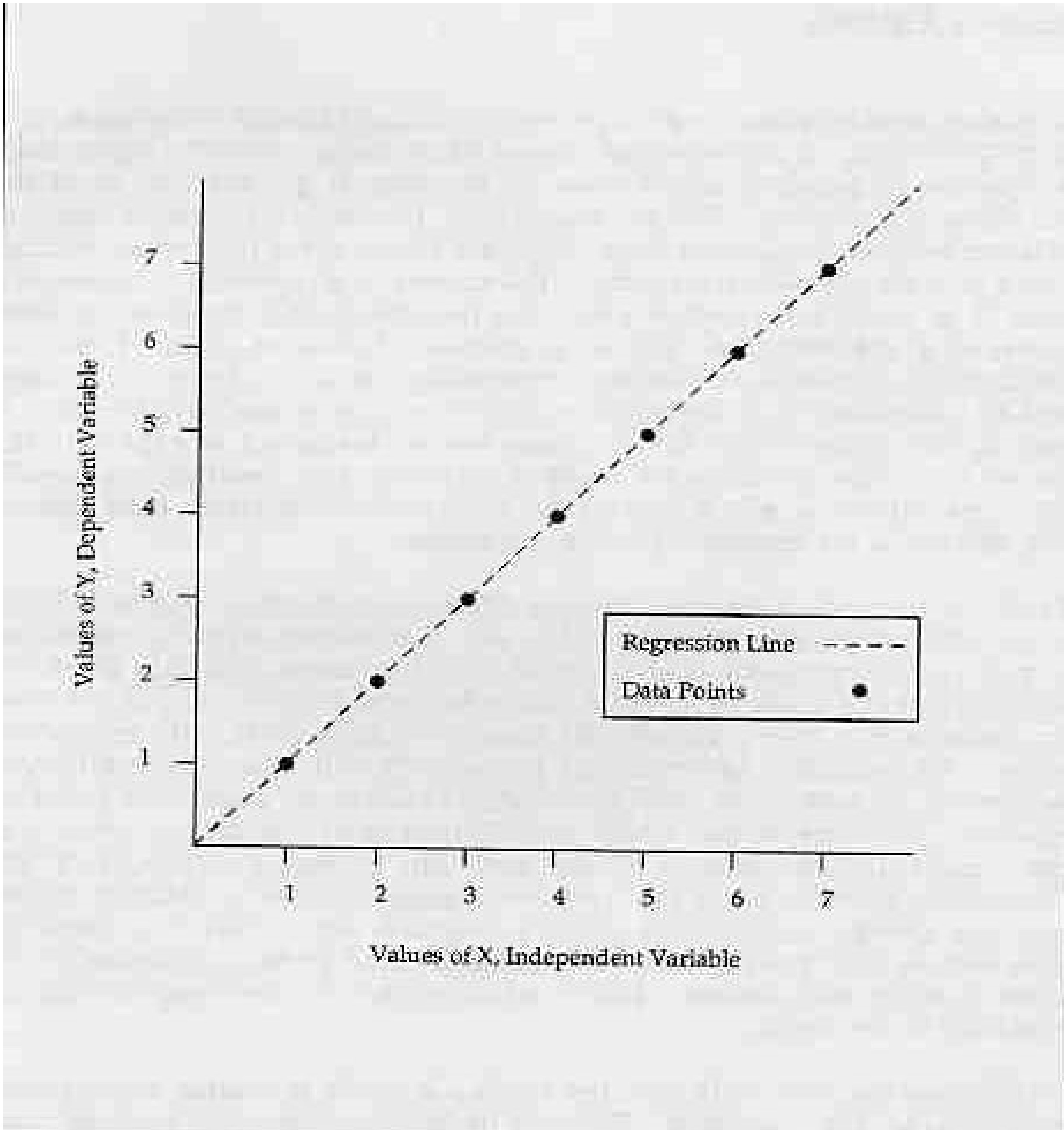

Figure 23. Scatterplot of perfect regression

Correlational Analysis

A statistic closely related to R^2 is Pearson's Product-Moment Correlation, or *r* (Blalock 1972:376-385). It measures the degree of deviation around a linear least squares equation (regression) and informs on the general goodness of fit of the described linear relationship. R^2 is the square of *r*. Pearson's *r*, in simple terms, is the correlation between the observed and predicted values of the dependent variable and as such provides us with a measure of the success of a regression. Values of *r* range from -1 to 1, and this supplies a basis for determining the direction (positive or negative) of a relationship as well as its success. Values of -1 and 1 indicate perfect negative and positive correlations respectively, while a value of 0 indicates the complete independence of the variables (ie. the values of one variable are not influenced by the values of the other). Since we are interested in exploring the goodness of fit of the variables for possible inclusion in a multiple regression analysis, *r* constitutes a much preferable means of comparison than simple regression and this is the method we use in this section.

Table 25 presents a Pearson Product-Moment correlation matrix for the primary variables of the Interior Sample data set. Correlation matrices contain all possible pairwise comparisons in a specified set of variables and this gives the characteristic triangular shape to the table. Since the correlation of x to y is the same as the correlation of y to x a rectangular matrix would express only redundant information. An inspection of the matrix in Table 25 will reveal predominantly weak correlations for both of the variables we wish to use as the dependent variables in our models. These are SITE.2, which we will refer to as site density when it is convenient, and SITEd, distance to nearest site. The strongest correlation in the matrix is actually between these two variables, indicating that as distance to site decreases, site density increases at a fairly constant rate. This is a negative correlation and as such the two variables will be related to the remainder of the variable set in an inverse manner. This is made evident by observing the sign of each correlation in the matrix.

SITE.2 is related positively with the various diversity measures and distance to nearest drainage rank 3 soil type. Thus site density increases with increased soil patch diversity and with increased distances to drainage rank 3 soils. On the other hand, distance to nearest stream (STd) and distance to drainage rank 1 and 2 soils decreases as site density increases. Thus, sites are more prevalent near drainage rank 1 and 2 soils and also near streams. Moreover, site density increases with decreases in associated soil patch; that is, site density increases with better drained soils. The variable INT, or interface type, is also negatively correlated with site density. It will be remembered that this variable was ranked according to our own assumptions about the type of interfaces that would be optimal for site location. Ecotonal interfaces were assigned a value of 1, dry interfaces were assigned a value of 2, and wet interfaces, which were regarded as the least optimal, were assigned a value of 3. Thus, there is an association between ecotonal and dry interfaces and greater site densities. SITEd is related to all of these variables in an inverse manner, as we would expect, because shorter distances to sites indicate a greater site density.

Table 25. Correlation (*r*) matrix of variables, Interior Sample.

	SITE.2	SITEd	STd	Hx	H.30	H.20	H.10	H.05	DR5	DR4	DR3	DR2	DR1	INT	NEAR	DRO
SITE.2	1.00															
SITEd	-0.58	1.00														
STd	-0.14	0.14	1.00													
Hx	0.22	-0.19	0.02	1.00												
H.30	0.21	-0.17	-0.02	0.79	1.00											
H.20	0.21	-0.15	0.04	0.87	0.75	1.00										
H.10	0.16	-0.14	0.04	0.83	0.44	0.59	1.00									
H.05	0.10	-0.13	0.01	0.69	0.26	0.36	0.64	1.00								
DR5	-0.09	0.02	-0.15	-0.38	-0.45	-0.36	-0.24	-0.14	1.00							
DR4	0.04	-0.01	-0.06	-0.21	-0.11	-0.17	-0.21	-0.19	-0.22	1.00						
DR3	0.22	-0.18	-0.06	-0.09	0.00	-0.05	-0.14	-0.10	-0.15	0.07	1.00					
DR2	-0.27	0.20	0.10	-0.37	-0.47	-0.36	-0.20	-0.13	0.21	-0.24	-0.21	1.00				
DR1	-0.24	0.16	0.25	-0.39	-0.49	-0.37	-0.19	-0.17	0.12	-0.09	-0.27	0.57	1.00			
INT	-0.39	0.30	0.16	-0.24	-0.33	-0.24	-0.11	-0.07	0.20	-0.25	-0.39	0.51	0.40	1.00		
NEAR	-0.09	0.08	0.03	-0.47	-0.15	-0.27	-0.52	-0.58	0.08	0.13	0.14	0.06	0.07	0.04	1.00	
DRO	-0.24	0.22	0.14	-0.07	-0.15	-0.09	-0.03	0.06	-0.02	-0.27	-0.19	0.33	0.27	0.49	-0.07	1.00

Examining other variable relationships in Table 25, we note that the diversity measures are highly correlated. They are, in fact, variably autocorrelated as they are computationally interdependent. That is, the calculation of each involves an additive input from the others. The diversity variable of least interdependence is H.05, which does not rely on the others for its measurement. In multiple regression it is imperative that variables of high interdependence be segregated and as such it would not be proper to use these variables, at least those other than H.05, in the same equation.

The non-site relationships provide a basis for understanding the structure of the environment. Nearly all diversity variables are related negatively to soil interface distance variables. We would expect this to be true because distances to different soil patch drainage ranks will decrease as the number of soil patches in a given search radius increases. DR1 and DR2 exhibit a fairly high positive correlation, indicating that they tend to occur together, since an increase in one is accompanied by a fairly regular increase in the other. DR2 is negatively correlated with DR3 and DR4, indicating that drainage ranks 3 and 4 occur away from soil patches of drainage rank 2, although these correlations are fairly weak. Interface type (INT) is positively correlated with DR1 and DR2 and negatively correlated with DR3 and DR4. This is not particularly meaningful because these variables are interdependent. Wet interfaces require soils of drainage ranks 3, 4, and 5, while dry ones require the presence of drainage ranks 1 and 2. Distance to nearest soil interface, NEAR, is not correlated with the soil drainage rank variables, but is negatively correlated with the diversity variables. We would expect this because soil interface distances should decrease with increased soil patch diversity. Distance to nearest stream, STd, exhibits very low correlations across the board.

A number of factors may contribute to the relatively low correlations we see in Table 25. Two factors, in particular, which appear to contribute to this are non-linear distributions and scale differences. One method of correcting for non-linear distributions is provided by an alternative correlation statistic called Spearman's Rho, or rank order correlation coefficient (Blalock 1972:416-418). This is a non-parametric statistic that evaluates trends of association by transforming continuous data into rank groupings, thereby diminishing the effects of individual, low level deviations. Table 26 presents a Spearman's rank correlation matrix for the Interior Sample. We can see that the correlations are generally strengthened by this analysis. However, the problem with using ranked data transformations in a model that we wish to standardize for common applications is that there is no set method for forming the ordinal groupings. We used a statistical package called DATA DESK to automatically form data ranks, but there is no guarantee that other statistical packages will form ranks in precisely the same manner.

Another method of smoothing and scaling data is logarithmic transformation. After some experimentation we arrived at the conclusion that a LOG10 transformation produced the highest correlations and these are presented in Table 27. These transformed variables are identified with the prefix @L? to differentiate them from the raw variables. As we see, these log transformations produce correlations of the same order as Spearman=s Rho. Both are an improvement over the raw variable correlations.

Tables 28 and 29 present Pearson=s Product-Moment Correlation (*r*) matrices for the raw and transformed LOG10 variables of the Maritime Sample. Again we see that the correlations are generally low and are improved by LOG10 transformations. SITE.2 and SITEd show the same strong negative correlation as we saw for the Interior Sample. Again we see that site density (SITE.2) is positively correlated with the diversity variables and is negatively correlated with most of the soil drainage rank distance variables. Especially strong are the correlations with DR2 and DR3. There is very little relationship between the distances to the poorer drained soils (ie. DR4, DR5, and DR6) and site density. Distance to nearest soil interface (NEAR) presents a fairly high correlation for both site variables. This is also true for DR0.

Table 26. Spearman's rank correlation (Rho) matrix of variables, Interior Sample.

	SITE.2	SITEd	STd	Hx	H.30	H.20	H.10	H.05	DR5	DR4	DR3	DR2	DR1	INT	NEAR	DRO
SITE.2	1.00															
SITEd	-0.58	1.00														
STd	-0.14	0.14	1.00													
Hx	0.22	-0.19	0.02	1.00												
H.30	0.21	-0.17	-0.02	0.79	1.00											
H.20	0.21	-0.15	0.04	0.87	0.75	1.00										
H.10	0.16	-0.14	0.04	0.83	0.44	0.59	1.00									
H.05	0.10	-0.13	0.01	0.69	0.26	0.36	0.64	1.00								
DR5	-0.09	0.02	-0.15	-0.38	-0.45	-0.36	-0.24	-0.14	1.00							
DR4	0.04	-0.01	-0.06	-0.21	-0.11	-0.17	-0.21	-0.19	-0.22	1.00						
DR3	0.22	-0.18	-0.06	-0.09	0.00	-0.05	-0.14	-0.10	-0.15	0.07	1.00					
DR2	-0.27	0.20	0.10	-0.37	-0.47	-0.36	-0.20	-0.13	0.21	-0.24	-0.21	1.00				
DR1	-0.24	0.16	0.25	-0.39	-0.49	-0.37	-0.19	-0.17	0.12	-0.09	-0.27	0.57	1.00			
INT	-0.39	0.30	0.16	-0.24	-0.33	-0.24	-0.11	-0.07	0.20	-0.25	-0.39	0.51	0.40	1.00		
NEAR	-0.09	0.08	0.03	-0.47	-0.15	-0.27	-0.52	-0.58	0.08	0.13	0.14	0.06	0.07	0.04	1.00	
DRO	-0.24	0.22	0.14	-0.07	-0.15	-0.09	-0.03	0.06	-0.02	-0.27	-0.19	0.33	0.27	0.49	-0.07	1.00

Table 27. Correlation (r) matrix of transformed Log10 variables, Interior Sample.

	LSITE.2	LSITEd	LSTd	LHx	LH.30	LH.20	LH.10	LH.05	LDR5	LDR4	LDR3	LDR2	LDR1	LINT	LNEAR	LDRO
LSITE.2	1.00															
LSITEd	-0.63	1.00														
LSTd	-0.15	0.11	1.00													
LHx	0.23	-0.20	-0.10	1.00												
LH.30	0.22	-0.19	-0.07	0.79	1.00											
LH.20	0.21	-0.14	-0.05	0.86	0.72	1.00										
LH.10	0.16	-0.13	-0.09	0.80	0.38	0.55	1.00									
LH.05	0.11	-0.13	-0.11	0.65	0.23	0.33	0.63	1.00								
LDR5	-0.09	0.06	-0.08	-0.44	-0.37	-0.35	-0.32	-0.31	1.00							
LDR4	0.12	-0.11	0.07	-0.12	0.04	-0.04	-0.16	-0.24	-0.16	1.00						
LDR3	0.25	-0.18	-0.07	0.07	0.20	0.10	-0.05	-0.06	-0.21	-0.09	1.00					
LDR2	-0.32	0.29	0.10	-0.27	-0.35	-0.25	-0.12	-0.08	0.09	-0.43	-0.52	1.00				
LDR1	-0.26	0.21	0.15	-0.40	-0.43	-0.38	-0.23	-0.18	0.03	-0.09	-0.37	0.13	1.00			
LINT	-0.37	0.30	0.19	-0.23	-0.30	-0.22	-0.10	-0.06	0.16	-0.24	-0.63	0.69	0.36	1.00		
LNEAR	-0.15	0.19	0.11	-0.48	-0.16	-0.25	-0.52	-0.68	0.33	0.25	0.10	0.07	0.11	0.05	1.00	
LDRO	-0.28	0.33	0.06	-0.13	-0.20	-0.15	-0.06	0.03	-0.18	-0.45	-0.31	0.51	0.59	0.49	-0.04	1.00

Correlations of the environmental variables point to structural patterns in the coastal ecosystem. Diversity variables are negatively correlated with distances to most drainage rank variables. The highest correlations occur with the better drained soils (ie. DR1, DR2, and DR3). The exception is DR6, which is positively correlated with diversity. This indicates that distance to salt marsh increases with increased diversity. This pattern is primarily a function of measuring control points well out into the marsh, resulting in a number of low diversity points represented almost solely by salt marsh soils. Distance to nearest soil interface, NEAR, is highly correlated with diversity, especially mean diversity (Hx). Distance to nearest stream, STd, is poorly correlated with diversity and most soil drainage rank variables. It has a high negative correlation with DR5, which is expected because this drainage rank is associated with creek bottom soils. NEAR is positively correlated with DR0, indicating that as distance to nearest soil interface decreases, so does the drainage rank of the associated soil type.

Table 28. Correlation (r) matrix of variables, Maritime Sample.

	Site.2	Site d	STd	Hx	H.30	H.20	H.10	H.05	DR6	DR5	DR4	DR3	DR2	DR1	INT	Near
Site.2	1.00															
Site d	-.66	1.00														
STd	-.09	.15	1.00													
Hx	.33	-.38	.16	1.00												
H.30	.26	-.28	.22	.80	1.00											
H.20	.32	-.37	.17	.88	.74	1.00										
H.10	.27	-.34	.05	.83	.43	.60	1.00									
H.05	.20	-.25	.04	.70	.30	.40	.66	1.00								
DR6	-.21	.14	.37	.14	.23	.14	.04	.03	1.00							
DR5	-.08	.02	-.47	-.46	-.60	-.46	-.23	-.14	-.45	1.00						
DR4	.07	.12	-.09	-.41	-.19	-.32	-.42	-.42	-.18	-.11	1.00					
DR3	-.25	.16	-.33	-.54	-.65	-.54	-.30	-.17	-.39	.85	-.18	1.00				
DR2	-.21	.34	-.14	-.71	-.56	-.63	-.60	-.49	-.22	.28	.33	.36	1.00			
DR1	.16	.00	.00	-.44	-.49	-.38	-.29	-.23	-.23	.32	.17	.30	.31	1.00		
INT	-.08	.12	-.04	-.23	-.19	-.20	-.16	-.21	-.09	.14	-.07	.18	.52	.32	1.00	
Near d	-.25	.38	-.01	-.64	-.40	-.49	-.60	-.62	-.13	.07	.65	.09	.50	.23	.03	1.00
DR0	-.20	.32	-.09	-.53	-.40	-.45	-.43	-.41	-.39	.29	.30	.37	.55	.33	.39	.41

Another factor that depresses the correlations in the data sets is the reliability of the site data. There is a problem of accuracy at the borders of the survey areas, as we discussed previously, and we developed a variable, Coverage Radius (CR), to help control for this potential source of error. The underlying assumption here is that as coverage radius increases, so does confidence in our ability to measure site density (SITE.2) and nearest distance to site (SITEd). The site distributions along the margins of the surveyed areas are unknown and hence we are less certain of the actual site densities at locations with smaller coverage radii. Tables 30 through 33 display the progression of correlations on these variables for specified coverage radii. The coverage radii cut-offs we selected for the Interior Sample were .25, .30, .35, .40, and .45 miles, while the Maritime cut-offs were .30, .60, .90, and 1.20 miles. As can be seen, the correlations improve with larger radii and this suggests that a more precise and accurate model can be generated from subsamples of the data bases in which the points with smaller coverage radii are eliminated.

An examination of the tables, and Figures 24 and 25, indicate that certain thresholds exist in these progressions. In the case of the Interior Sample, the correlation coefficients generally level off at a coverage radius of .35 miles. There is a substantial difference between the .30 subsample and the .35 sample and although there are cases where the correlations advance in the .40 and .45 mile subsamples, the differences are slight and do not compensate for the reduced sample sizes we would encounter if we chose these larger radii for modelling. In the case of the Maritime Sample, the cut-off would appear to be positioned at a coverage radius between about .60 and .90 miles. A problem with relying on the larger coverage radii in the Maritime Sample is that they become increasingly biased by remote salt marsh control points. In addition, the Maritime Sample is much smaller and

Table 29. Correlation (r) matrix of transformed Log10 variables, Maritime Sample.

	LSITE.2	LSITEd	LSTd	LHx	LH.30	LH.20	LH.10	LH.05	LDR6	LDR5	LDR4	LDR3	LDR2	LDR1	LINT	LNEAR
LSITE..2	1.00															
LSITE d	-.59	1.00														
LSTd	-.17	.23	1.00													
LHx	.39	-.30	.05	1.00												
LH.30	.31	-.18	.08	.83	1.00											
LH.20	.38	-.27	.07	.89	.76	1.00										
LH.10	.32	-.30	.01	.81	.45	.61	1.00									
LH.05	.23	-.23	.00	.67	.32	.41	.66	1.00								
LDR6	-.04	.08	.39	.33	.36	.32	.22	.15	1.00							
LDR5	.03	-.08	-.36	-.37	-.45	-.35	-.19	-.13	-.41	1.00						
LDR4	.09	-.01	-.09	-.19	-.04	-.12	-.24	-.31	-.32	-.13	1.00					
LDR3	-.20	.12	-.19	-.38	-.43	-.36	-.24	-.14	-.42	.50	-.32	1.00				
LDR2	-.23	.26	-.11	-.54	-.40	-.44	-.47	-.46	-.34	.10	.01	.03	1.00			
LDR1	-.06	.06	.09	-.40	-.37	-.34	-.29	-.27	-.20	.09	.06	-.04	.16	1.00		
LINT	-.08	.11	-.05	-.18	-.14	-.15	-.12	-.19	-.19	-.02	.00	-.20	.61	.32	1.00	
LNEAR	-.27	.39	.07	-.53	-.27	-.35	-.54	-.69	-.03	.06	.37	.13	.39	.20	.08	1.00
LDR0	-.24	.30	-.11	-.51	-.40	-.44	-.43	-.41	-.57	.18	.01	.28	.64	.52	.41	.35

the largest coverage radii entail too drastic a reduction in sample size. A cut-off of .60 miles would appear to be an acceptable compromise since the disparity in sample size between the .60 mile and that of the .90 mile subsamples is respectively 292 cases to 175 cases.

Table 30. Progression of correlations by coverage radius (CR) for LSITE.2 and environmental variables, Interior Sample

	LSITE.2(All)	LSITE.2 (.25)	LSite.2 (.30)	LSite.2 (.35)	LSite.2 (.40)	LSite.2(.45)
LSITE.2	1.00	1.00	1.00	1.00	1.00	1.00
LSITEd	-.63	-.69	-.71	-.75	-.77	-.76
LSTd	-.15	-.25	-.27	-.23	-.21	-.20
LHx	.23	.36	.42	.50	.50	.50
LH.30	.22	.30	.35	.45	.48	.47
LH.20	.21	.31	.37	.44	.45	.43
LH.10	.16	.28	.32	.36	.35	.35
LH.05	.11	.25	.29	.33	.29	.32
LDR5	-.09	-.15	-.19	-.21	-.22	-.18
LDR4	.12	.25	.28	.29	.33	.32
LDR3	.25	.27	.26	.25	.22	.17
LDR2	-.32	-.50	-.54	-.57	-.56	-.53
LDR1	-.26	-.32	-.33	-.34	-.34	-.34
LINT	-.37	-.51	-.51	-.55	-.54	-.51
LNEAR	-.15	-.26	-.29	-.31	-.27	-.26
LDRO	-.28	-.43	-.46	-.51	-.50	-.51

Table 31. Progression of correlations by coverage radius (CR) for LSITEd and environmental variables, Interior Sample

	LSITEd(All)	LSITE.d (.25)	LSite d (.30)	LSite d(.35)	LSite d(.40)	LSite d (.45)
LSITEd	1.00	1.00	1.00	1.00	1.00	1.00
LSTd	.11	.18	.16	.21	.20	.18
LHx	-.20	-.32	-.38	-.45	-.47	-.46
LH.30	-.19	-.29	-.35	-.44	-.48	-.47
LH.20	-.14	-.24	-.29	-.33	-.35	-.33
LH.10	-.13	-.26	-.29	-.33	-.34	-.33
LH.05	-.13	-.23	-.25	-.32	-.29	-.31
LDR5	.06	.07	.07	.08	.07	.05
LDR4	-.11	-.25	-.29	-.28	-.30	-.28
LDR3	-.18	-.17	-.14	-.16	-.10	-.09
LDR2	.29	.47	.51	.56	.53	.50
LDR1	.21	.28	.32	.34	.34	.33
LINT	.30	.40	.41	.49	.45	.42
LNEAR	.19	.27	.29	.32	.30	.28
LDRO	.33	.49	.56	.55	.54	.52

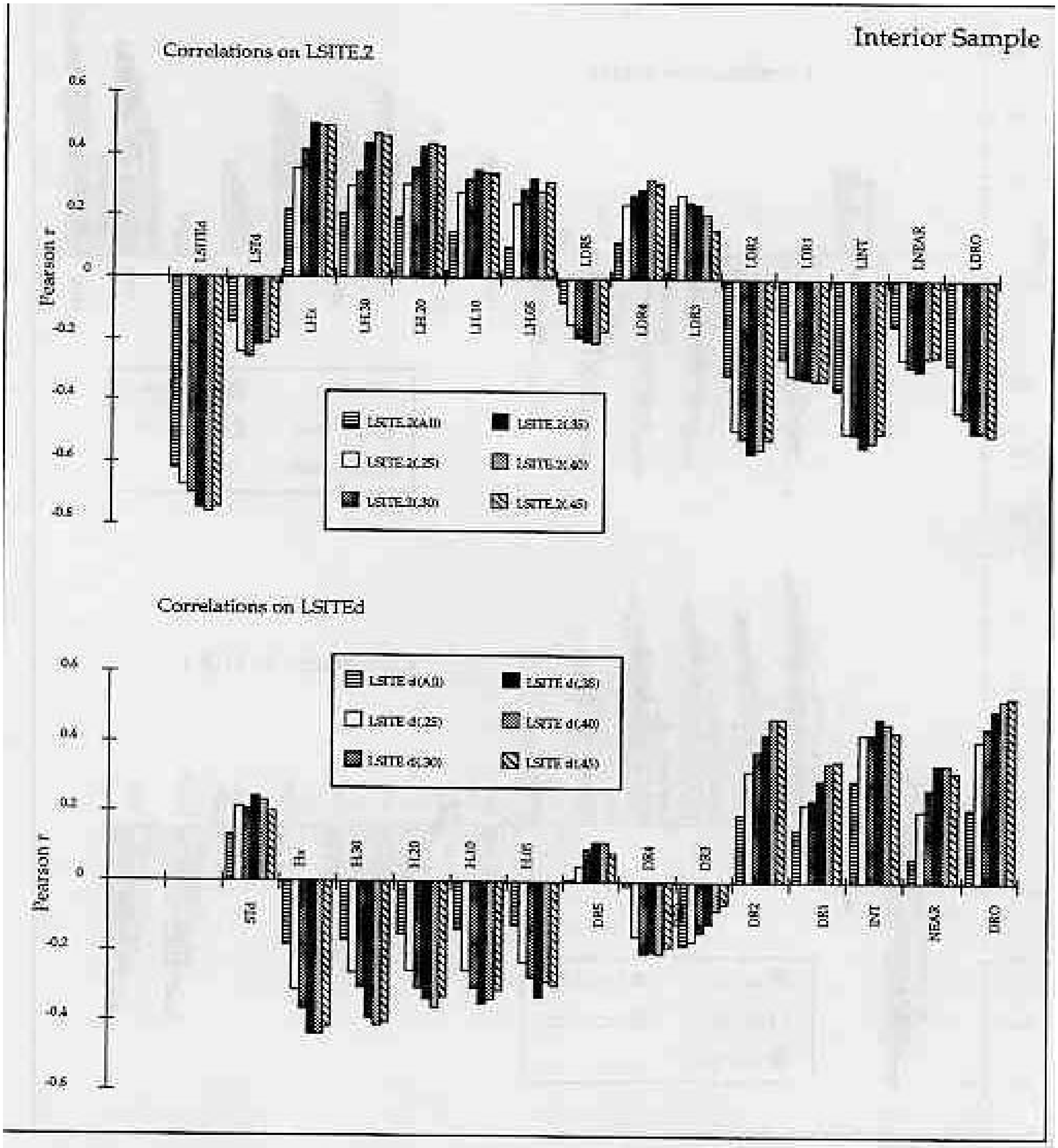

Figure 24. Progression of correlation coefficients (r) for coverage radii, Interior Sample

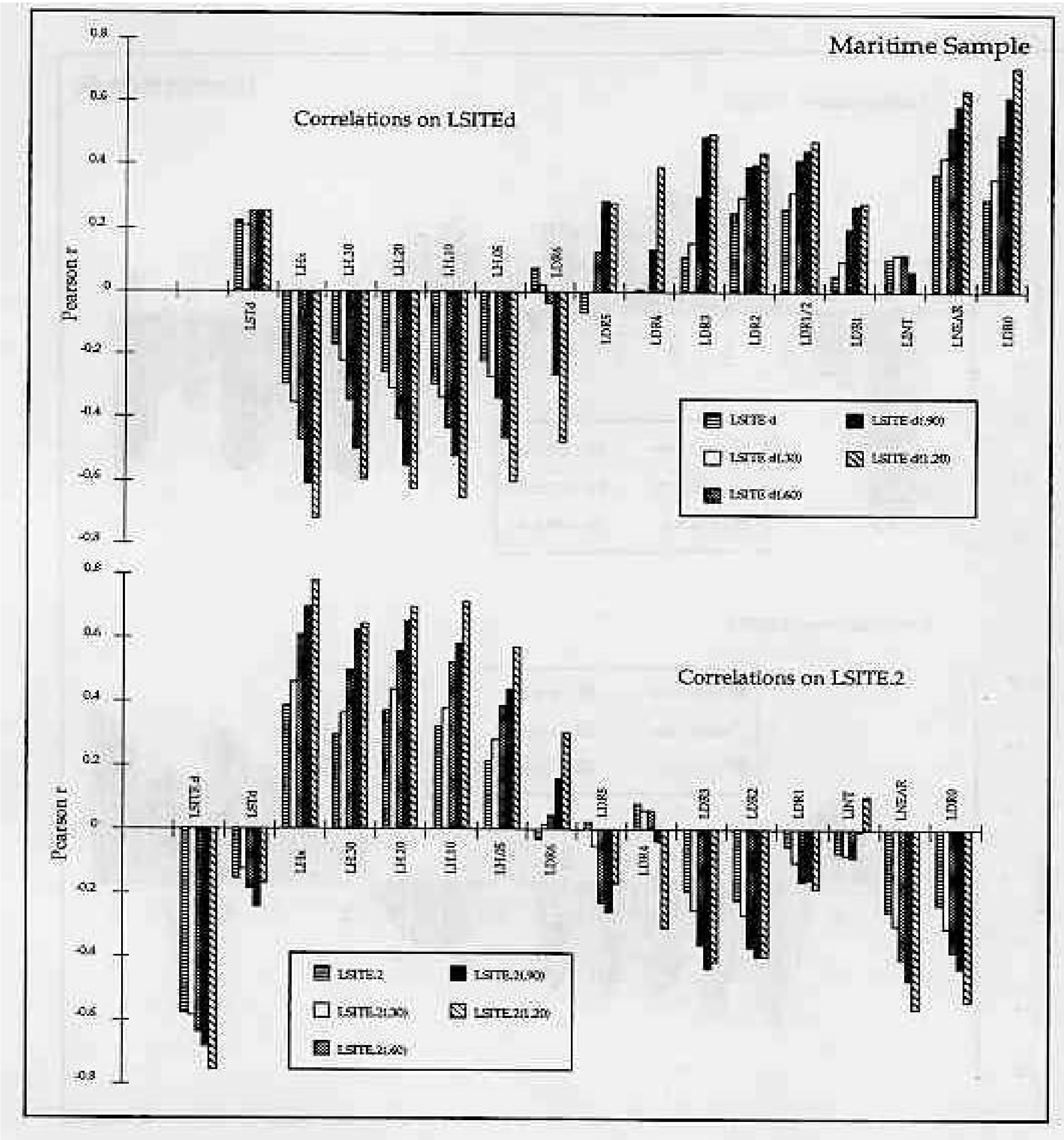

Figure 25. Progression of correlation coefficients (r) for coverage radii, Maritime Sample

The preceding analysis has provided the reader with a fundamental awareness of the variable relationships and limitations of the data sets. It has also outlined some of the special techniques applied to this data base to prepare it for multiple regression analysis. A LOG10 transformation of the data smoothed the effects of non-linear distributions and scale differences in the structure of the variables. Moreover, elimination of lower confidence cases greatly increased the strength of the correlations. The pairwise correlations are, in general, flatter than perfect correlations and as such a relatively large amount of deviation around the regression line is extant. This does not mean, however, that the variables are not useful in predicting site location, only that we must accept a large error range. This is to be expected in a complex problem like the one on which this study focuses. Multiple regression can reduce this overall variability by combining the effects of a number of independent variables simultaneously. The next section will lay out the steps taken in the generation of the predictive equations for modelling site location in the Charleston Harbor watershed.

Table 32. Progression of correlations by coverage radius (CR) for LSITE.2 and environmental variables, Maritime Sample.

	LSite.2	LSite.2(.30)	LSite.2(.60)	LSite.2(.90)	LSite.2(1.20)
LSite.2	1.00	1.00	1.00	1.00	1.00
LSite d	-.59	-.59	-.64	-.69	-.76
LSTd	-.17	-.14	-.20	-.25	-.18
LHx	.39	.47	.62	.71	.79
LH.30	.31	.37	.51	.63	.66
LH.20	.38	.44	.57	.67	.71
LH.10	.32	.39	.53	.59	.72
LH.05	.23	.29	.39	.44	.58
LDR6	-.04	.02	.05	.16	.32
LDR5	.03	-.06	-.24	-.27	-.18
LDR4	.09	.07	.07	-.05	-.32
LDR3	-.20	-.26	-.37	-.44	-.42
LDR2	-.23	-.28	-.38	-.41	-.41
LDR1	-.06	-.11	-.17	-.16	-.20
LINT	-.08	-.09	-.10	-.02	.11
LNear d	-.27	-.31	-.41	-.48	-.57
LDR0	-.24	-.32	-.39	-.45	-.55

Table 33. Progression of correlations by coverage radius (CR) for LSITEd and environmental variables, Maritime Sample.

	LSite d(All)	LSite d(.30)	LSite d(.60)	LSite d(.90)	LSite d(1.20)
LSite d	1.00	1.00	1.00	1.00	1.00
LSTd	.23	.21	.25	.26	.25
LHx	-.30	-.36	-.48	-.62	-.73
LH.30	-.18	-.23	-.35	-.51	-.60
LH.20	-.27	-.31	-.41	-.56	-.63
LH.10	-.30	-.35	-.44	-.53	-.66
LH.05	-.23	-.28	-.35	-.47	-.61
LDR6	.08	.03	-.05	-.28	-.49
LDR5	-.08	-.01	.13	.30	.28
LDR4	-.01	.01	-.01	.14	.40
LDR3	.12	.16	.31	.50	.51
LDR2	.26	.31	.40	.41	.45
LDR1/2	.27	.32	.42	.46	.49
LDR1	.06	.11	.20	.28	.29
LINT	.11	.12	.12	.07	-.01
LNear d	.39	.43	.53	.60	.64
LDR0	.30	.37	.51	.62	.72

Multiple Regression Models

A series of multiple regression trial runs were made to determine the best-fit combination of variables for constructing model equations for the Interior and Maritime Samples. The variables with the greatest predictive value were anticipated from the associational and correlational analyses we discussed above, although determining the optimal mix required experimentation. Some statistical packages provide an option known as *stepwise regression* which automatically builds a regression model through the addition or deletion of predictor variables according to statistical thresholds. The package we used, DATA DESK, does not provide this option. However, this was not a major problem with the data sets we constructed since the relationships were rather simple and intuitively obvious.

Separate models were generated for a number of different subsamples based on coverage radius cut-off points as described in the last section. An expected result was that as coverage radius increased and sample size decreased, R^2 increased. Figure 26 illustrates the trend in Adjusted R^2 values for the various best-fit solutions at a given coverage radius. Values increase from about 17 percent to slightly more than 46 percent in the Interior Sample and level off at a coverage radius of 0.35 miles. Values increase from about 25 to 68 percent for the Maritime Sample, but continue to climb with increased coverage radius. There is no leveling off.

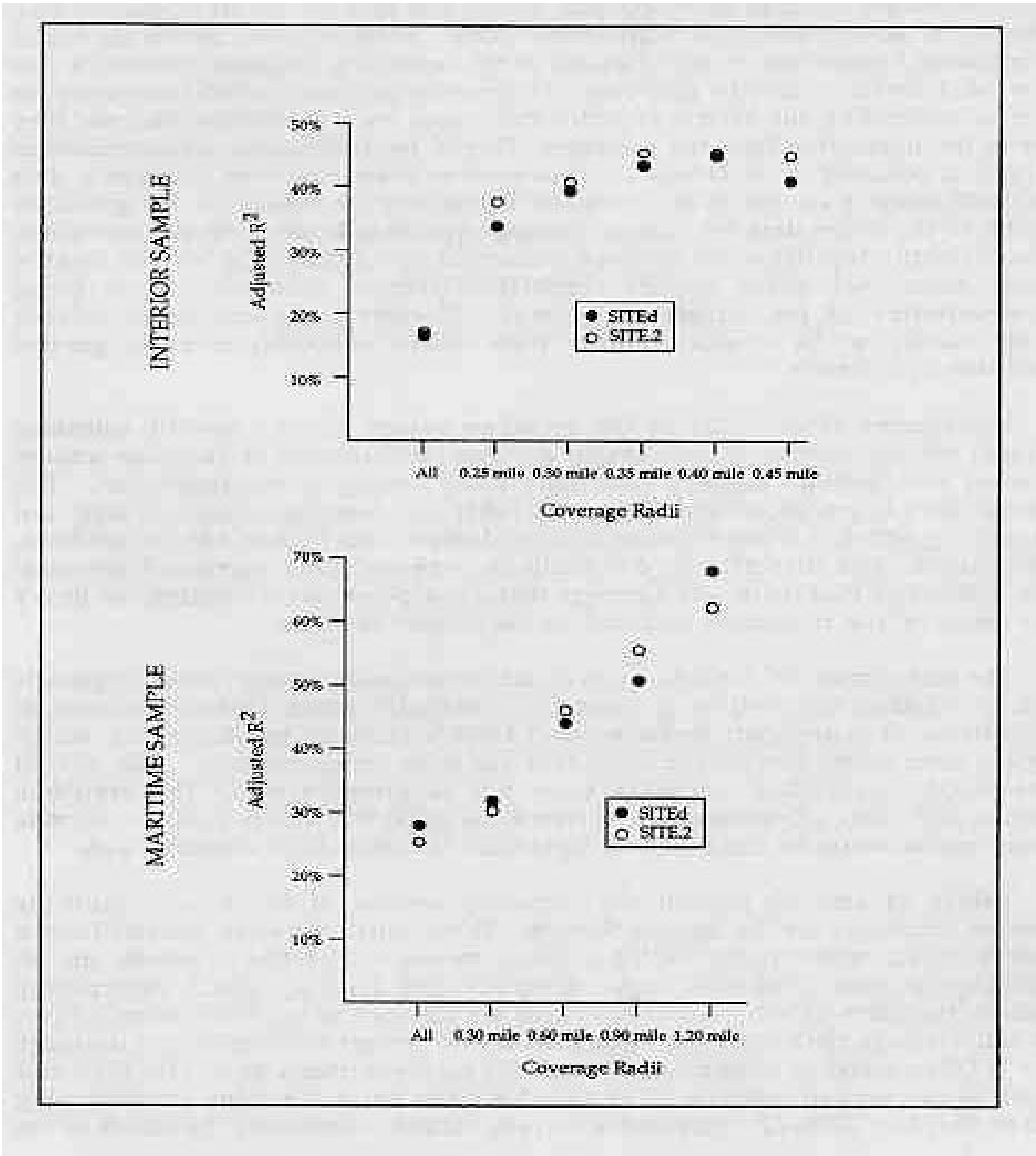

Figure 26. Progression of adjusted R^2 values for coverage radii

Once the best-fit solutions were generated the data bases were checked for extreme or aberrant cases. It is a characteristic of correlational analyses that they are disproportionately influenced by extreme values and this can result in the artificial weakening or strengthening of a true relationship. Extreme cases can be identified by examining histograms of each variable or by examining diagnostic statistics that can be calculated on a case by case basis. Diagnostics provide a much more effective means of evaluating the effects of individual cases on a regression because they factor in the interaction between variables. One of the diagnostics we examined in this light is referred to as *Leverage*. This statistic measures how extreme a data point's influence is on the final regression by relating its values on the predictor variables to the entire data set. Larger leverage values indicate more extreme cases. A rule of thumb stipulates that leverage values above 0.5 should be used to identify extreme cases that might require elimination from a data set due to being unrepresentative of the sample in general. However, elimination of smaller leverage values can be considered when they deviate noticeably from the general distribution in a sample.

Histograms (Figure 27) of the leverage values for the best-fit solutions generated for the Interior Sample reveal a normal distribution of very low values, indicating that individual cases contribute fairly evenly to the regression. The Maritime Sample produced equations with fairly low leverage values as well, but there was a great deal more variation in their distributions (Figure 28). In addition, the magnitude and disparity in distributions increased with increased coverage radius, indicating that there was a danger that a few points were exerting too heavy an influence on the regression solutions in the smaller samples.

The same trends in the data bases could be seen using several other diagnostic statistics, including the plotting of studentized residuals, which identify extremes in the predicted or dependent variables, and Cook=s Distance measurement, which considers both dependent and independent variables simultaneously. The overall effects on the dependent variables were not as pronounced in the Maritime equations and Cook's Distance measurement indicated that either a .30 or .60 mile coverage radius could be used without significant influence from extreme cases.

Tables 34 and 35 present the summary reports of the best-fit multiple regression equations for the Interior Sample. These equations were derived from a subsample of all control points with a coverage radius of .35 miles or greater and all archaeological sites from the larger sample. The two equations incorporate essentially the same LOG10 variables. These are distance to nearest stream (LSTd), mean soil drainage rank diversity (LHx), distance to nearest soil interface of drainage rank 4 (LDR4), distance to nearest soil drainage rank of either 1 or 2 (LDR1/2), and distance to nearest soil interface (LNEAR). DR0 also has some value for predicting SITEd or LSITEd. LDR1/2 represents a derived variable combining the effects of the better drained soils. This was done to eliminate analytical noise due to the fact that DR1 patches are very spotty in distribution throughout the watershed. This created situations in which DR1 patches were located at great distances from a project area, even though when present in project areas they were generally situated very near sites and adjacent to DR2 soils. DR1/2 records the distance from either DR1 or DR2, whichever is closer.

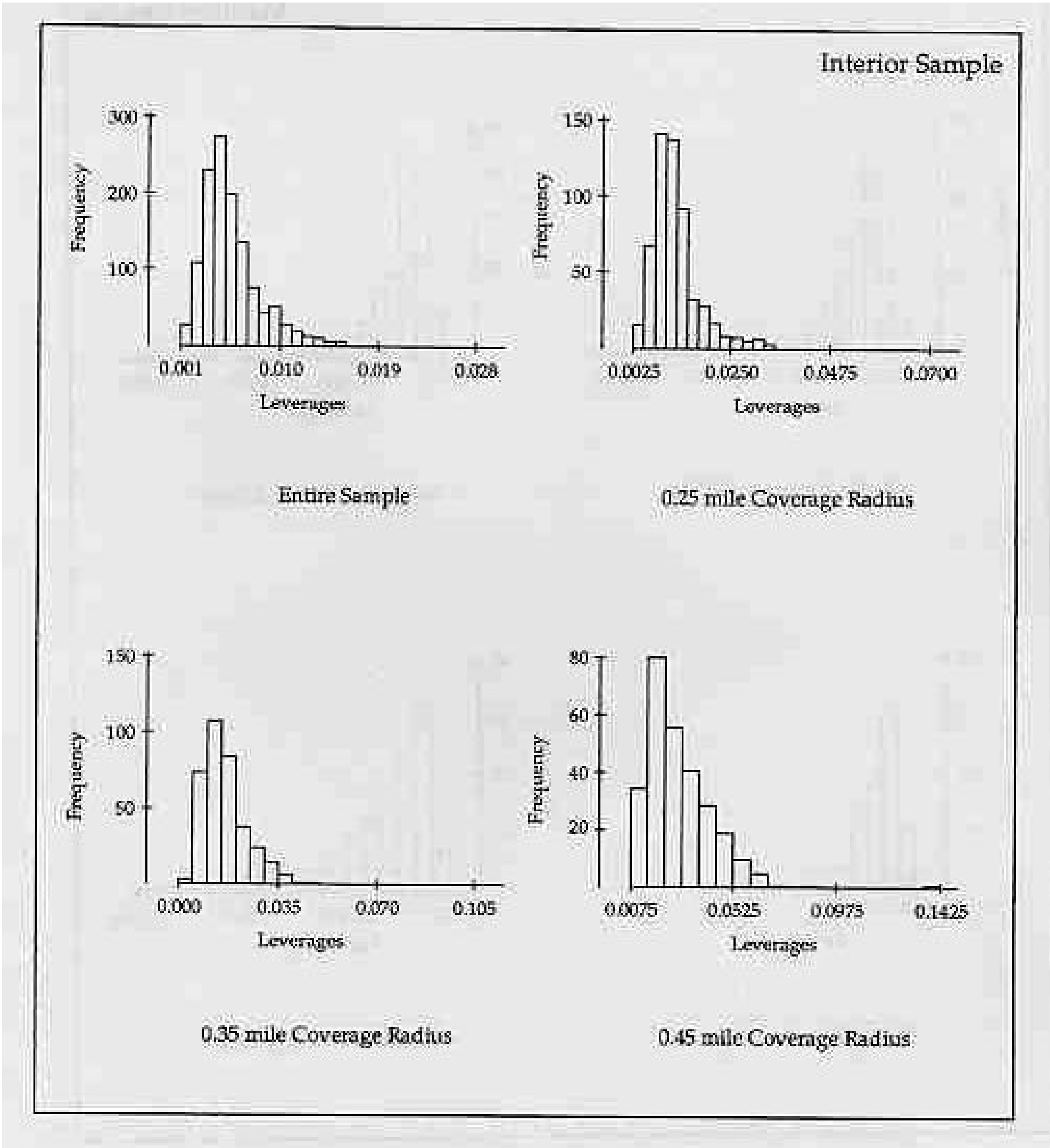

Figure 27. Histograms of leverage values, Interior Sample

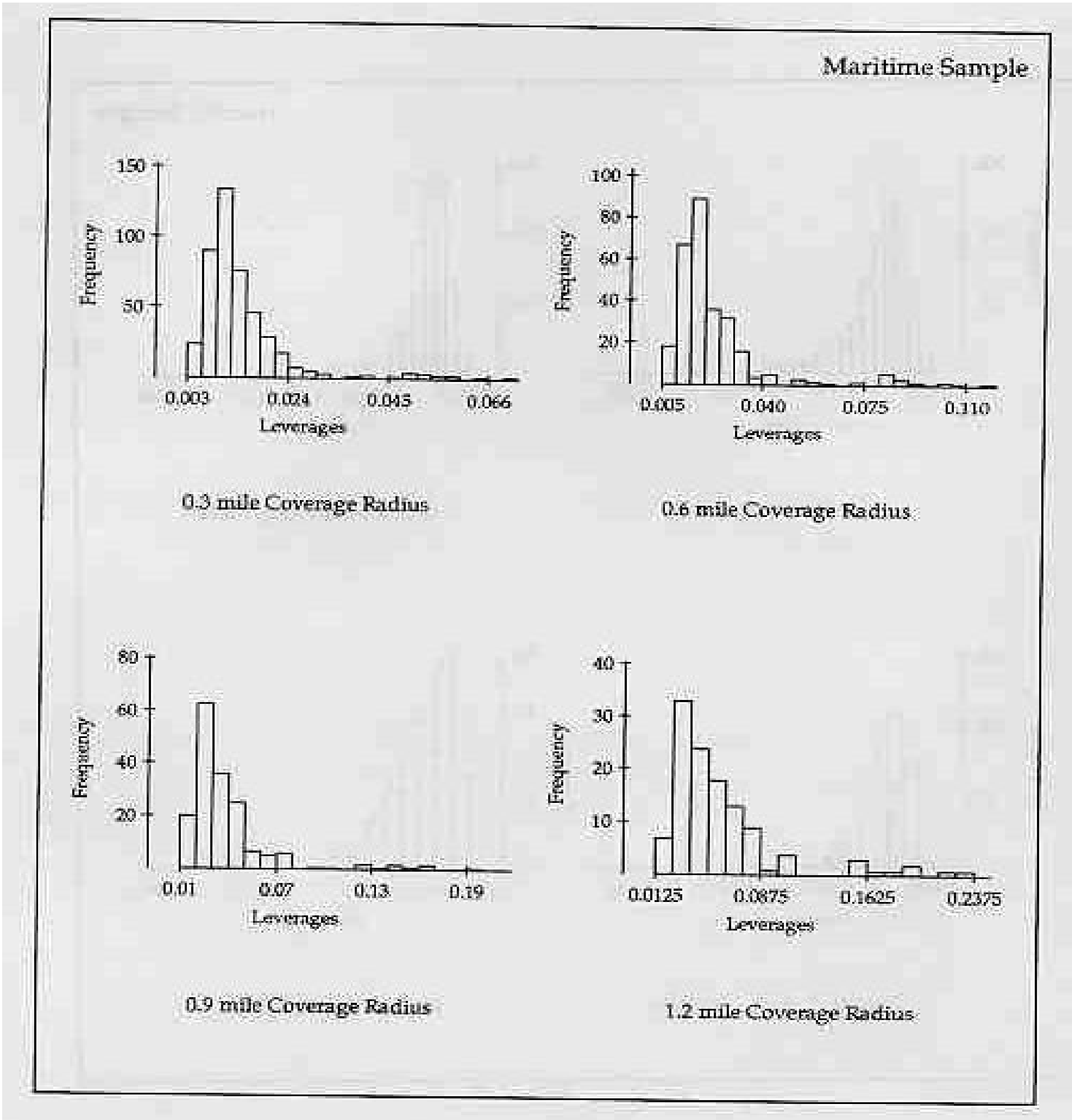

Figure 28. Histograms of leverage values, Maritime Sample

A regression summary table contains numerous kinds of statistical information to evaluate the effectiveness of the associated equation. The coefficient of determination, R^2, as we have noted, is an expression of the percent of the variability in the dependent variable explained by the equation. A quick reference to the tables will show that this value is actually the sum of squares of the regression divided by the total sum of squares (ie. for both the regression and residual sources). In the two equations presented here, R^2 explains only a little less than 50 percent of the variability in the two site variables. This is lower than we would have liked, but it should not be concluded that the equations are of little use to us. In fact, we will see in the next section that they perform fairly well in identifying areas of high and low site potential. There is obviously a large amount of the variability still unexplained and we have already mentioned some of the likely sources that would add definition to our model if we were to develop analytical programs to identify and control their measurement.

Table 34. Multiple regression summary table of LSITE.2 on LSTd, LHx, LDR4, LDR1/2, and LNEAR, Interior Sample.

Dependent variable is: LSITE.2
R^2 = 46.2% R^2 (adjusted) = 45.5%
s = 0.4137 with 360 - 6 = 354 degrees of freedom

Source	Sum of Squares	df	Mean Square	F-ratio
Regression	52.1311	5	10.43	60.9
Residual	60.5902	354	0.171159	
Variable	Coefficient	s.e. of Coeff	t-ratio	
Constant	-0.947954	0.0938	-10.1	
LSTd	-0.116274	0.0536	-2.17	
LHx	0.852889	0.2655	3.21	
LDR4	0.090858	0.0300	3.02	
LDR1/2	-0.191720	0.0233	-8.24	
LNEAR	-0.132135	0.0434	-3.05	

Table 35. Multiple regression summary table of LSITEd on LSTd, LHx, LDR4, LDR1/2, LNEAR, and LDRO, Interior Sample.

Dependent variable is: LSITE d
R^2 = 44.4% R^2 (adjusted) = 43.5%
s = 0.8933 with 360 - 7 = 353 degrees of freedom

Source	Sum of Squares	df	Mean Square	F-ratio
Regression	225.066	6	37.5	47.0
Residual	281.674	353	0.797942	
Variable	Coefficient	s.e. of Coeff	t-ratio	
Constant	-0.971604	0.3159	-3.08	
LSTd	0.189586	0.1160	1.63	
LHx	-0.971347	0.5751	-1.69	
LDR4	-0.161797	0.0652	-2.48	
LDR1/2	0.308267	0.0670	4.60	
LNEAR	0.362877	0.0942	3.85	
LDRO	1.20792	0.4363	2.77	

The F-ratio in the summary reports evaluates whether the overall regression is statistically significant. Consultation with standard F-distribution tables indicates that both of these regressions are significant at a probability of less than .01, given 6 and 354 and 7 and 353 degrees of freedom respectively. In other words, both regressions appear to reflect legitimate patterns of covariation.

The coefficients associated with each variable represent the unit of change for each independent variable relative to a unit change in the dependent variable, *after removing the linear effects of all other independent variables*. Each of these represents a *slope coefficient* as described for the simple regression model above. The constant is the *intercept coefficient* of that model. The *t*-ratios evaluate the statistical significance of each coefficient. All of the coefficients in these equations are significant at the .05 level of probability for a one-tailed *t*-test, with the exception of LSTd in the SITEd equation (Table 35). The critical *t*-ratio is 1.645 and the *t*-ratio for LSTd is just under this at 1.63. We decided to allow this variable to remain in the equation, however, because it was felt that the effects of stream proximity might increase the overall utility of the model. In general, then, all of the independent variables appear to influence the linear prediction of the dependent variables.

The resulting equations take the following form:

(1) LSITE.2 = -0.947954 + (-0.116274 x LSTd) + (0.852889 x LHx) + (0.090858 x LDR4) + (-0.19172 x LDR1/2) + (-0.132135 x LNEAR).

(2)LSITEd = -0.971604 + (0.189586 x LSTd) + (-0.971347 x LHx) + (-0.161797 x LDR4) + (0.308267 x LDR1/2) + (0.362877 x LNEAR) + (1.20792 x LDRO).

These equations represent the sum of the constant, or *intercept coefficient*, and the products of the variable coefficients and the LOG10 transformations of the variable values. For any measured control point or site, then, a predicted value of the LOG10 transformations of site density (LSITE.2) or distance to nearest site (LSITEd) can be calculated simply by plugging the variable values derived at that point into these equations.

Extrapolating from the variable relationships in the models, we can conclude the following about site location in the Interior stratum of the Charleston Harbor watershed. Archaeological sites will be found in greater densities in locations of high soil drainage rank diversity, near soil interfaces, especially at ecotonal interfaces between soil patches of drainage ranks 1 or 2 and 4. Nearness to streams factors into this equation as well, but it has only a weak influence on prediction.

Tables 36 and 37 contain the best-fit multiple regression equation summaries for the Maritime Sample. These were generated from a subsample of 292 cases consisting of all archaeological sites and those control points associated with a coverage radius of greater than or equal to 0.60 miles. The equations are again expressed in terms of LOG10 transformations. Both equations have R^2 values comparable to those derived for the Interior equations. Each explains a little less than half of the variability contained in the dependent variables (ie. LSITE.2 and LSITEd). Both are explained best by the same set of six independent variables. These include distance to nearest stream (LSTd), mean soil drainage rank diversity (LHx), soil drainage rank diversity at a search radius of 0.05 miles (H.05), distance to soil drainage ranks of 6 (LDR6) and 1 (LDR1), and soil drainage rank association (DR0). Although there is some interdependence between the calculations of mean diversity and .05 radius diversity, it was felt that the influence of each on site density was primarily independent, as the former characterizes immediate point diversity, while the other measures a broader catchment of diversity.

An evaluation of the components of the equations indicates that the independent variables strongly influence the prediction of site density and site proximity. The F-ratios are large and have associated probabilities of less than .01, which argues that there is little chance that the relationships stipulated in the model occur by chance. Moreover the *t*-ratios indicate significance at probability levels of .01 or less, which means that all of the independent variables exert significant influence in the prediction of the dependent variables. The multiple regression equations for the Maritime Sample can be expressed in the following form:

(1) LSITE.2 = -1.26294 + (-0.199682x LSTd) + (3.51543 x LHx) + (-0.508256 x LH.05) + (-0.185025 x LDR6) + (0.22531 x LDR1) + (-0.972209 x LDR0).

(2) LSITEd = -1.5015 + (0.446929 x LSTd) + (-2.92139 x LHx) + (-0.699786 x LH.05) + (0.346784 x LDR6) + (-0.427669 x LDR1) + (3.43849 x LDR0).

Table 36. Multiple regression summary table of LSITE.2 on LSTd, LHx, LH.05 LDR6, LDR1, and LDRO, Maritime Sample.

Dependent variable is: LSite.2
292 total cases of which 2 are missing
R^2 = 47.3% R^2 (adjusted) = 46.2%
s = 0.4777 with 290 - 7 = 283 degrees of freedom

Source	Sum of Squares	df	Mean Square	F-ratio
Regression	57.9487	6	9.658	42.3
Residual	64.5847	283	0.228214	
Variable	Coefficient	s.e. of Coeff	t-ratio	
Constant	-1.26294	0.2113	-5.98	
LSTd	-0.199682	0.0587	-3.40	
LHx	3.51543	0.3288	10.7	
LH.05	-0.508256	0.2101	-2.42	
LDR6	-0.185025	0.0387	-4.78	
LDR1	0.225310	0.0628	3.59	
LDR0	-0.972209	0.2314	-4.20	

Table 37. Multiple regression summary table of LSITEd on LSTd, LHx, LH.05 LDR6, LDR1, and LDRO, Maritime Sample.

Dependent variable is: LSite d
292 total cases of which 2 are missing
R^2 = 45.4% R^2 (adjusted) = 44.3%
s = 0.7647 with 290 - 7 = 283 degrees of freedom

Source	Sum of Squares	df	Mean Square	F-ratio
Regression	137.673	6	22.9	39.2
Residual	165.480	283	0.584734	
Variable	Coefficient	s.e. of Coeff	t-ratio	
Constant	-1.50150	0.3383	-4.44	
LSTd	0.446929	0.0940	4.75	
LHx	-2.92139	0.5262	-5.55	
LH.05	0.699786	0.3362	2.08	
LDR6	0.346784	0.0619	5.60	
LDR1	-0.427669	0.1005	-4.26	
LDR0	3.43849	0.3704	9.28	

The implications of these equations are that archaeological sites on the coastal fringe of the Charleston Harbor watershed will be situated in locations of broad catchment soil drainage diversity, but also in locations where the immediate point diversity (LH.05) is low. This would suggest that sites will be situated on wide, well drained landforms adjacent to large, poorly drained soil patches. This locational principal is supported by the fact that locations of greater site density are associated with soils of lower drainage rank (ie. better drained soils). Moreover, site density will increase with proximity to salt marsh, which constitutes the highest proportion of poorly drained soils adjacent to well drained landforms. Distance to streams would also appear to have a greater influence on site densities than it did in the Interior Sample.

It is quite obvious from an inspection of the equations for both the Interior and Maritime Samples that the two dependent variables, LSITE.2 and LSITEd, have very similar solutions. The same independent variables are used and the corresponding coefficients for each are of relatively equal magnitude. In fact, if we generate scatterplots for the predicted values of each variable for the two samples we find that there is very little difference in the way the two equations measure site potential from point to point (Figure 29). The correlation for the predicted values of the two variables for the Interior Sample is nearly perfect ($r = -.981$), while that of the Maritime Sample is also very high ($r = -.904$). Corresponding R^2 values for the comparisons indicate that 96 percent of the variability in each of the predicted site variables (LSITE.2P and LSITEdP) is explained by the other in the Interior Samples, while 82 percent of the variability is explained in the Maritime Sample. This indicates that Interior equations measure almost exactly the same thing, while there is some variation in the Maritime equations. We will examine these relationships further in the next section, along with the more important issue of the accuracy of the models.

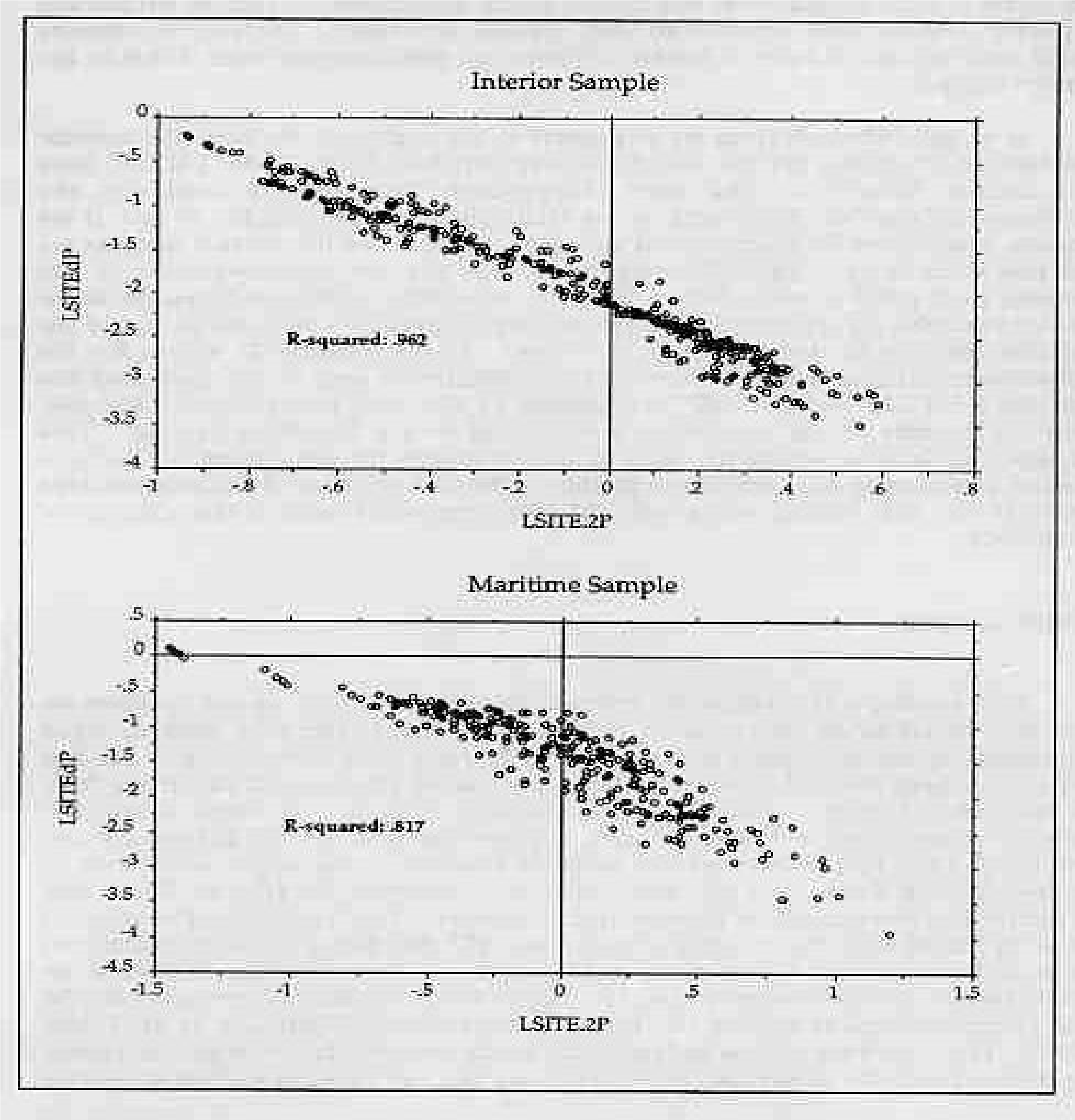

Figure 29. Scatterplots of correlations between LSITE.2P and LSITEdP for the best fit multiple regression equations

Model Testing

This section will examine the effectiveness of the models of site location we have developed using independent data from tracts of land that have received archaeological survey deploying modern site discovery field methodology. For this purpose we have selected three tracts from the Interior stratum and two tracts from the Maritime stratum. The Interior tests derive from two locations along Gal Branch and southeast of the community of Jamestown, SC on the Francis Marion National Forest (Figure 30) and one location situated in the upper watershed of Wadboo Swamp Creek near the community of Cordesville, SC (Figure 31). These are referred to respectively as Interior Tests 1, 2 and 3. Test 1 consists of contiguous stands in Forest Service Compartments 122 and 123 and Test 2 includes contiguous stands in Forest Service Compartments 122 and 140. Test 3 consists of three tracts within Forest Service Compartment 75. All of these locations were surveyed by New South Associates during the Hugo Salvage Survey (Williams et al. 1992b, 1993b). The Maritime tests were also situated in Francis Marion National Forest. The first includes the contiguous Sewee Fire and Salt Pond tracts near Forest Service Compartment 200, south of the community of Awendaw, SC (Figure 32). The former tract was surveyed by Brockington and Associates (Gardner 1992), while the Salt Pond tract was surveyed by New South Associates (Cable et al. 1995). The second test is represented by the South Tibwin tract, situated on the west side of Tibwin Creek, south and west of McClellanville, SC (Figure 33). This tract was also surveyed by New South Associates (Cable et al. 1995).

Figure 30. Project map of Interior Tests 1 and 2

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Figure 31. Project map of Interior Test 3

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The method of testing we will present in this section is essentially the same procedure one would use to evaluate an unsurveyed tract. The appropriate section of SCS soil maps are scanned and transferred to a CAD file. Then the boundaries of the development tract are rescaled and overlaid on the soil map within the CAD file. Next a grid of measurement points spaced at 0.1 mile intervals is overlaid on the soil and tract layers. It is advisable to extend the grid a good distance beyond the tract so that the skewing that occurs in contouring algorithms at the boundaries of the map data will not be manifest within the tract. The variables described in Chapter V are then measured and recorded at each grid node and these data are entered onto a spread sheet file. Once the spread sheet is completed it is a simple matter to calculate the predicted values of LSITE.2 and LSITEd for each node or control point using the multiple regression equations discussed above. These values can then be imported into a contouring program, we used the MACGRIDZO program here, where site potential contours can be mapped. These contour maps can then be imported into the CAD file where they can be layered into the base map to demarcate the precise locations of the site potential isotherms within the development tract. Since we know the real site distributions in the these test locations, we will also be able to view first hand how successful the equations are in modelling site location.

Before moving ahead to testing the models, however, it is necessary to define exactly what the isotherms we will generate actually represent. Since we will be using a contouring algorithm, the resulting isotherms will represent arbitrary boundaries in a continuous array of points across the landscape. We will rank these isotherms in accordance with their relative value in predicting site location according to the models, but they will not represent probability zones *per se*. Probability zones, as commonly formulated, represent polygons that contain the same probability of occurrence throughout. The probability of finding a site

at one location within the zone is the same as any other location within the zone. In our application the probability of occurrence fluctuates from one location to the next in each isotherm. Within any isotherm band, the locations closer to the next highest ranking isotherm have higher probabilities of site occurrence than locations nearer the next lower isotherm. Moreover, the data we will present do not reflect explicit probabilities of site occurrence, only relative ones. Thus, we cannot say precisely what the probability of finding a site at any specific site location will be, only that the location has a high or low ranking for site occurrence relative to other locations in the vicinity. This will become clearer as we discuss the tests below.

Figure 32. Project map of Maritime Test 1

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Figure 33. Project map of Maritime Test 2

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Interior Tests

Figures 34 through 39 illustrate site occurrence isotherms for the two predicted variables on sample grids covering the three Interior test tracts. As we discussed above, these isotherms represent arbitrary divisions of continuous values that are constructed in the same exact manner as topographic contours on a U.S.G.S. map. We have highlighted these particular isotherms as a visual aid for identifying areas of predicted lower and higher site occurrence and we have assigned ranked values of high, medium, and low site occurrence to these isotherms. It will be noted that the sample limits have been expanded from the surveyed limits in each case so that the @boundary effects? of contouring algorithms could be diminished in the main area of the test localities. The griding algorithm we used tends to project trends at the edges of the mapping field and as a consequence it can distort the magnitude of value changes here. This can create isotherms of exaggerated and misleading values along the borders of the map. Expanding the mapping field reduced the effect of this phenomenon within the surveyed areas and provided us with a reliable basis for evaluating the success of the models. The spreadsheet data bases for the three Interior Tests are presented in Appendices E, F, and G.

Interior Test 1 consisted of a grid area of 0.8 x 1.4 miles, and resulted in the recording of 135 control points (Figures 34 and 35). Both predicted variables (LSITE.2P and LSITEdP) show a large area of low site occurrence in the center of the surveyed tracts and much smaller areas of medium and high site occurrence on the northwest and northeast boundaries. Visually, the six archaeological sites identified during survey tend to be located in the high and medium site occurrence isotherms. True to the Interior equations, these latter isotherms are situated in locations of greater soil patch diversity and soil interfaces between well and poorly drained soils.

A grid measuring 1.0 x 1.8 miles was overlaid on Interior Test 2, resulting in a data base of 228 control points (Figures 36 and 37). The high and medium site occurrence isotherms for LSITE.2P and LSITEdP are most prevalent on the eastern side of the grid. This portion of the grid contains a number of small stream drainages, ecotonal soil interfaces, and high soil patch diversity. The western side of the grid, by contrast, consists primarily of large patches of drainage rank 3 soils and low soil patch diversity. While there is a general agreement of site occurrence isotherms and the distribution of the 18 identified sites in the survey tracts, there are also two anomalous disjunctions.

First, the northern area of low occurrence contains an unusually large number of sites. This is an area that also contains small streams, but the general soil structure is of fairly low soil drainage diversity. One factor that may be at play here is variation within a single soil drainage rank. Three separate soil types (Wahee loam, Lenoir fine sandy loam, Lynchberg fine sandy loam) of drainage rank 3 occur in this general area and it is quite possible that one or more of these soil types differ significantly in their drainage characteristics. If we were to have access to more specific data on soil drainage we might find that these soils represent a gradation of drainage that would place them at intermediate positions between ranks 2 and 4. This situation might indicate a greater diversity of soil drainage patches than our present data can distinguish and thus explain the unexpectedly large number of sites in this particular location.

Figure 34. Distribution of LSITE.2P, Interior Test 1

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Figure 35. Distribution of LSITEdP, Interior Test 1

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Figure 36. Distribution of LSITE.2P, Interior Test 2

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Figure 37. Distribution of LSITEdP, Interior Test 2

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Figure 38. Distribution of LSITE.2P, Interior Test 3

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Figure 39. Distribution of LSITEdP, Interior Test 3

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Secondly, there is an area of predicted high site occurrence in the center of the survey tracts that does not contain sites. An inspection of the soil map at this location reveals that all conditions are present that would lead us to anticipate high to medium site occurrence, including high soil patch diversity and ecotonal interfaces. This may point to some aspect of site location not well defined by the models. Alternatively, it could indicate sampling error wherein the presence of sites were mistakenly undetected by 30 meter interval shovel testing. This is a common problem with shovel testing as a site discovery technique (Krakker et al. 1983; Nance and Ball 1986; Lightfoot 1986; McManamon 1984).

Interior Test 3 consisted of a 1.4 x 1.6 mile grid of 255 control points (Figures 38 and 39). There is a general tendency in this test area for identified sites, of which there are 10, to be associated with the high and medium site occurrence isotherms as well. The LSITE.2P distribution appears to predict site location better than does the LSITEdP distribution. Half of the sites in the latter distribution are actually situated in the low occurrence isotherm, but we also see that these particular sites are located very near the medium occurrence isotherm. As such, this area is characterized by high site occurrence values relative to the entire distribution of the low occurrence isotherm. Selection of different contour intervals would distinguish these particular locations from areas of lower site occurrence.

This points to an aspect of the isotherms that must be appreciated. There are no single contour values that distinguish one occurrence isotherm from another. We selected isotherms that tended to divide the map fields into relatively equal areas of site occurrence. Other divisions, of course, could be made. The objective, however, was to break the fields into isotherms that would supply analytical advantage in distinguishing the occurrence characteristics of relatively large areas. Exaggerating the distribution of any particular isotherm will tend to dilute our ability to identify and differentiate isotherms of significant size for planning purposes.

Although there is an intuitive appreciation of the effectiveness of the models to predict site location, we need a basis for quantitatively evaluating this. One method that is at once straight-forward and also capable of controlling for representativeness, consists of comparing site densities by isotherm area. If the models are effective in distinguishing site occurrence divisions, then we would expect higher site densities in isotherms of higher site occurrence ranking. We examined this hypothesis by measuring the area covered by each isotherm *within the surveyed tracts* in each test location and calculating the site frequency density for each. Tables 38 and 39 present the results of this analysis for the distributions of LSITEdP and LSITE.2P as depicted in Figures 34 through 39. We see that both models conform very well to this hypothesis. The high site occurrence isotherms are characterized by the highest site densities, while the medium and low site occurrence isotherms contain respectively intermediate and low site densities.

A statistical test of these results can be obtained by comparing the proportions of archaeological sites and areas of site occurrence isotherms for each test location. This is essentially the same comparison as site density, but it has been reformatted to accommodate the structure of a Chi-square test. The raw data are presented in Table 40 and the results of the Chi-square tests are presented in Table 41. All comparisons are statistically significant and have associated Cramer=s V values that indicate moderately strong to very strong relationships. This confirms our general hypothesis that site density is highest in high occurrence isotherms and lowest in low occurrence isotherms. The progression, however, is not completely linear in form, because the distinctions between the medium and high occurrence isotherms are not as clear. Table 42 presents the results of Chi-square tests comparing site densities between the high and medium site occurrence isotherms only. Here we see that not all comparisons are significant, but that the LSITE.2P variable shows greater discriminatory power. Two of the three are statistically significant in the LSITE.2P comparisons and the direction of change is as hypothesized (ie. higher site densities are obtained in the high site occurrence isotherm). Only one comparison is significant in the LSITEdP variable.

From these comparisons we can conclude that the models are very effective in discriminating low site occurrence from medium and high site occurrence. However, there is a lesser degree of success in discriminating medium from high occurrence isotherms. Only one of the three tests could differentiate high and medium site occurrence using the distribution of LSITEdP values. The LSITE.2P distribution was more effective in distinguishing these isotherms, as two of the three comparisons were consistent with our expectations. We can suggest that over the long run the LSITE.2P variable will be successful in making the distinction between medium and high site occurrence, but the same conclusions cannot be made for LSITEdP. As such we would recommend the use of the LSITE.2P variable in predicting site location on Interior tracts.

Table 38. Site density for LSITEdP by site occurrence isotherm, Interior tests.

Test Location	Area (acres)	Sites(n)	Site Density/per acre
Interior Test 1			
High	7	1	0.143
Medium	29	3	0.103
Low	109	2	0.018
Interior Test 2			
High	113	6	0.053
Medium	320	7	0.022
Low	357	5	0.014
Interior Test 3			
High	20	1	0.050
Medium	193	9	0.050
Low	38	0	0.000

Table 39. Site density for LSITE.2P by site occurrence isotherm, Interior Tests.

Test Location	Area(acres)	Sites(n)	Site Density/per acre
Interior Test 1			
High	3	1	0.330
Medium	62	4	0.065
Low	80	1	0.013
Interior Test 2			
High	136	7	0.051
Medium	350	6	0.017
Low	304	5	0.016
Interior Test 3			
High	33	3	0.091
Medium	105	7	0.067
Low	111	0	0.000

Maritime Tests

Figures 40 through 43 illustrate the site occurrence isotherms for the two Maritime tests. Test 1 consists of a 1.0 x 1.4 mile grid overlaid on the contiguous Sewee and Salt Pond tracts. The data base contains 165 control points and is presented as Appendix H in the back of this report. Test 2 is a grid of 1.3 x 1.3 miles overlaid on the South Tibwin tract. This data base contains 196 control points and is presented as Appendix I.

Table 40. Proportional comparison of archaeological site area and area of site occurrence isotherms, Interior Tests.

	LSITEdP		LSITE.2P	
Test Location	% Sites	% Area	%Sites	%Area
Interior 1				
High	17	5	17	2
Medium	67	20	50	43
Low	17	75	33	55
Interior 2				
High	33	14	39	17
Medium	39	41	33	44
Low	28	45	28	39
Interior 3				
High	10	8	30	13
Medium	90	78	70	42
Low	0	15	0	46

Table 41. Results of Chi-square comparisons of percentage of archaeological sites by percentage of site occurrence isotherm areas, Interior Tests.

	LSITEdP				LSITE.2P			
Location	df	X^2	p*	CV	df	X^2	p*	CV
Interior 1	2	68.5	0.0001	0.58	2	17.9	0.0001	0.30
Interior 2	2	11.7	0.0029	0.24	2	12.0	0.0025	0.25
Interior 3	2	16.1	0.0003	0.28	2	59.7	0.0001	0.55

* Significant comparisons are underlined

Table 42. Results of Chi-square comparisons of percentage of archaeological sites by percentage area for high and medium site occurrence isotherms only, Interior Tests.

	LSITEdP				LSITE.2P			
Location	df	X^2	p*	Phi	df	X^2	p*	Phi
Interior 1	1	0.0	0.979	0.00	1	8.4	0.0038	0.27
Interior 2	1	5.6	0.018	0.21	1	9.4	0.0022	0.27
Interior 3	1	0.3	0.873	0.01	1	0.8	0.3972	0.07

* Significant comparisons are underlined

Test 1 is characterized by large and numerous sites, including Salt Pond Plantation, a late eighteenth-early nineteenth century out plantation containing also a prehistoric Mississippian village and Sewee Shell Ring, a Late Archaic ceremonial mound site. The mapping of both the LSITEdP and LSITE.2P variables show a fairly close correspondence between site distributions and site occurrence isotherms (Figures 40 and 41). The low occurrence isotherm contains only portions of small numbers of sites, while the medium occurrence isotherm includes most of the identified sites. The high occurrence isotherm is limited to the area around an intermittent marsh creek in the southern portion of the test field. Although it contains fewer sites than the medium occurrence isotherm, intuitively it would appear to contain a higher site density nonetheless.

Test 2 also contains a large number of sites. The largest of these are Mississippian village and hamlet segments. In contrast to Test 1, though, it also contains large void areas. Again, the bulk of the identified sites are situated in either the medium or high site occurrence isotherms (Figures 42 and 43). One anomaly is the concentration of large sites along Tibwin Creek and the salt marsh in the southern segment of the project area. This is an area of broad, relatively poorly drained soils of drainage rank 3 and the soil patch diversity as a result is low. This can be seen as a potential source of error in the model, as some locations of this sort will obviously have relatively high site density. However, the model intuitively appears to characterize site densities fairly well.

We will examine the effectiveness of the Maritime models for predicting site location in the same way we did for the Interior tests. Some modifications are in order, however, because of the large sizes of some of the sites in the tracts. This presents a problem because it often results in sites extending into two different isotherms. The solution we arrived at was to estimate the proportion of sites residing in each isotherm and crediting that fraction to the sum of sites for a particular isotherm. Fractions were calculated in 0.25 site increments. Another adjustment made to control for large sites in the Maritime sample was to calculate total site area within each isotherm. This resulted in two density measures, adjusted site frequency density and site area density.

Tables 43 and 44 present the site density data for the isotherms of site occurrence for LSITEdP and LSITE.2P. Both density measures show the expected increase from low to high site occurrence isotherms. Adjusted site frequency density tends to show a more consistent progression than site area density. In the latter case the densities for the medium occurrence isotherm overlap, at times, with both low and high occurrence isotherms.

Converting the density data to proportional data in Table 45 allows us to examine these associations from a statistical standpoint using Chi-square comparisons. Almost all of the 2 x 3 contingency table comparisons indicate significant and strong relationships (Table 46), confirming the general hypothesis that higher site densities will occur in medium and high site occurrence isotherms. The one exception is the comparison of site area density for LSITEdP in Maritime Test 1. Again, the models are less successful at discriminating medium from high occurrence areas. None of the 2 x 2 contingency table analyses comparing these two isotherms are significant for LSITEdP (Table 47). However, the comparisons of LSITE.2P for Maritime Test 2 did produce significant and strong results. Just as was true of the Interior models, LSITE.2P exhibits a greater degree of discrimination. This equation successfully discriminates low occurrence areas and appears to have greater potential for distinguishing between areas of medium and high site occurrence. Finally, site frequency density is more accurately characterized by the model equations than is site area density.

Figure 40. Distribution of LSITE.2P, Maritime Test 1

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Figure 41. Distribution of LSITEdP, Maritime Test 1

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Figure 42. Distribution of LSITE.2P, Maritime Test 2

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Figure 43. Distribution of LSITEdP, Maritime Test 2

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Table 43. Site frequency, site area and respective densities by LSITEdP site occurrence isotherm, Maritime tests.

Test Location	Area(ac)	Sites(n)	Site Area(ac)	Freq. Density	Area Density
Maritime Test 1					
High	33	3.5	6.66	.106	.202
Medium	192	14.0	40.96	.073	.213
Low	55	0.5	7.68	.009	.140
Maritime Test 2					
High	101	7.5	8.70	.074	.086
Medium	112	7.0	4.61	.063	.041
Low	226	5.5	7.17	.024	.032

Table 44. Site frequency, site area and respective densities by LSITE.2P site occurrence isotherm, Maritime tests.

Test Location	Area(ac)	Sites(n)	Site Area(ac)	Freq. Density	Area Density
Maritime Test 1					
High	24	3.75	9.10	.156	.379
Medium	163	13.25	38.03	.081	.233
Low	93	1.00	8.17	.011	.088
Maritime Test 2					
High	81	10.50	8.70	.130	.107
Medium	132	4.00	4.10	.030	.031
Low	226	5.50	7.68	.024	.034

Table 45. Proportions of archaeological site frequency and site area density by area of site occurrence isotherm, Maritime tests.

	LSITEdP			LSITE.2P		
Test Location	% Sites.	% Site Area	% Iso. Area	%Sites	%Site Area	%Iso. Area
Maritime 1						
High	19	12	12	21	16	9
Medium	78	74	69	74	69	58
Low	3	14	20	5	15	33
Maritime 2						
High	38	42	23	53	42	18
Medium	35	23	26	20	20	30
Low	28	35	52	30	38	52

Table 46. Results of Chi-square comparisons of proportions of archaeological site frequency and area by proportion of isotherm area, Maritime Tests.

	LSITEdP				LSITE.2P			
Location	df	X^2	p*	CV	df	X^2	p*	CV
Maritime 1								
Freq.	2	14.7	.0006	.27	2	27.4	.0001	.37
Area	2	1.2	.5410	.08	2	9.66	.0080	.22
Maritime 2								
Freq.	2	12.2	.0022	.25	2	25.1	.0001	.35
Area	2	9.05	.0108	.21	2	13.8	.0010	.26

* Significant comparisons are underlined

Table 47. Results of Chi-square comparisons of proportions of archaeological site frequency and site area by proportion of area of medium and high site occurrence isotherms only, Maritime Tests.

	LSITEdP				LSITE.2P			
Location	df	X^2	p*	Phi	df	X^2	p*	CV
Maritime 1								
Freq.	1	0.7	.4030	.06	1	2.0	.1620	.11
Area	1	0.3	.8740	.01	1	0.8	.3730	.07
Maritime 2								
Freq.	1	0.3	.5800	.05	1	14.7	.0001	.35
Area	1	3.5	.0590	.18	1	10.0	.0016	.30

* Significant comparisons are underlined

Limitations and Extensions of the Models

One of the more eloquent features of regression equations is that they provide a basis for predicting actual values of the dependent variable for any case. The models we have discussed, then, have the potential to supply us not only with zones of ranked site occurrence, but also with data on the expected site density at any single location in the Charleston Harbor watershed. This has dual ramifications. First, it can provide developers with a ballpark estimate of the numbers archaeological sites that may be present in their tracts. Second, it can facilitate archaeological research dealing with questions of land use intensity in various localities and microenvironments.

The test locations can again be used to evaluate the equations in terms of their effectiveness for estimating site density or prevalence. An initial comparison of the predicted (SITEdP and SITE.2P) and actual(SITEdA and SITE.2A) values for the dependent variables of the control points in the test localities does not indicate that the equations are of much use in characterizing true site densities. First of all, correlations between the variables are weak and only about half of them show significant regression relationships (Table 48). The raw data for the comparisons in Table 48 are presented respectively in Appendices J and K. Only those control points within the boundaries of the surveyed areas were included as these were the only locations where actual data for the dependent variables could be collected. The weak correlations indicate that our equations do not provide a firm basis for predicting site occurrence values at a specific point. Moreover, Table 49 indicates that the equations characteristically overestimate site density (SITE.2) and underestimate distance to nearest site (SITEd). Furthermore, most of the predicted variable samples are statistically different from the corresponding actual values (Table 50). For all of these comparisons the dependent variables were transformed from LOG10 to real values.

Precisely why the actual site occurrence values of the control points in the tests are overestimated by the equations is a matter of conjecture. However, it is likely that this results from an unrepresentative emphasis on points containing archaeological sites in the model samples. The influence of this practice, which was necessary to achieve a clear reading of the characteristics in the environment that associated with our dependent variables, on the equations can be readily appreciated. A large sample of SITEd values of 0 will tend to reduce the average nearest distance to sites and, since sites are clustered, we can surmise that there is a bias toward larger site density values in the model samples. The Maritime 1 test is the only one of five where the general trend is reversed. This was an unusually dense location to begin with and also rather special since it included in its site inventory Sewee Shell Ring, Salt Pond Plantation, and a relatively large Mississippian village. It is our hunch that Maritime 1 is not truly representative of the coastal environment as a whole and that Maritime 2 actually provides a better approximation of representative conditions.

Table 48. Correlations of predicted and actual site variables from test localities.

Test Locality	Comparison	r	R^2	F	p*
Maritime 1	SITE.2A vs SITE.2P	.230	.054	2.416	.1276
	SITEdA vs SITEdP	.024	.001	0.023	.8796
Maritime 2	SITE.2A vs SITE.2P	.341	.116	9.330	.0032
	SITEdA vs SITEdP	.298	.089	6.945	.0103
Interior 1	SITE.2A vs SITE.2P	.512	.262	8.519	.0075
	SITEdA vs SITEdP	.402	.162	4.632	.0417
Interior 2	SITE.2A vs SITE.2P	.135	.018	2.010	.1591
	SITEdA vs SITEdP	.168	.028	3.150	.0788
Interior 3	SITE.2A vs SITE.2P	.227	.052	1.469	.2360
	SITEdA vs SITEdP	.511	.261	7.778	.0107

* Significant (at .05 p) regressions are underlined.

Table 49. Summary statistics for predicted and actual site variables from test localities.

	SITEdA	SITEdP	SITE.2A	SITE.2P
Maritime 1	0.053_0.056	0.065_0.106	1.773_1.516	1.113_0.735
Maritime 2	0.147_0.125	0.020_0.025	1.066_1.382	2.490_1.782
Interior 1	0.144_0.093	0.009_0.004	0.673_0.857	0.893_0.217
Interior 2	0.199_0.124	0.025_0.023	0.571_0.867	0.975_0.609
Interior 3	0.113_0.087	0.016_0.023	0.879_0.995	1.162_0.458

The consistent trend toward over representation, though, suggests that it is possible to correct for this problem and to bring the predicted values into agreement with actuals using simple regression analysis. Reversing the order of prediction this time by designating the actual values as the dependent variables (SITE.2A and SITEdA) and the predicted values as the predictor or independent variables (SITE.2P and SITEdP), we can solve for a third variable (SITE.2Pc and SITEdPc) that we can call the corrected dependent variable. Using the data in Appendix J, we can derive the following equations to correct predicted values for the Interior Sample:

(1) SITE.2Pc = .31 + (.333 x SITE.2P) and (2) SITEdPc = .15 + (1.352 x SITEdP)

The corresponding regressions are weak (R^2 = .041 for SITE.2Pc and .056 for SITEdPc), but we are not interested here in the effectiveness of the equations to predict the exact value of individual points. We know from our study of site occurrence by isotherm area that the models are capable of identifying areas of differential site density. Instead, we are most interested in determining if the new equations can reduce the predicted mean values of the test localities to levels more in line with the actual values.

Table 50. Paired t-Test comparisons for predicted and actual site data, test localities.

Test Locality	Comparison	t-score	Probability
Maritime 1	SITE.2A vs SITE.2P	2.872	.0063
	SITEdA vs SITEdP		0.6540.516
Maritime 2	SITE.2A vs SITE.2P	6.591	.0001
	SITEdA vs SITEdP		8.983.0001
Interior 1	SITE.2A vs SITE.2P	1.456	.1578
	SITEdA vs SITEdP		7.486.0001
Interior 2	SITE.2A vs SITE.2P	4.358	.0001
	SITEdA vs SITEdP		40.817.0001
Interior 3	SITE.2A vs SITE.2P	1.526	.1383
	SITEdA vs SITEdP		6.172.0001

* Significant (at .05 p) regressions are underlined.

Table 51 presents the results of calculating this new variable for the Interior tests using the equations stipulated above. As one can see, the mean actual and predicted values correspond fairly closely with this correction. The standard deviations are reduced substantially due to the averaging effects of the regression equations, but in each case there is significant overlap between the ranges of the two variables (Figure 44) and we can tentatively conclude that these correction equations are effective in adjusting the magnitude of the predicted site occurrence variables so that they more accurately reflect actual values.

Unfortunately we could not derive a set of correction equations from more than one of the Maritime tests, because of the non-representative nature of the Salt Pond-Sewee Fire tract locality. We generated two additional regression equations using the more representative Maritime 2 test. These took the following form:

(1) SITE.2Pc = .408 + (.264 x SITE.2P) and (2) SITEdPc = .117 + (1.469 x SITEdP).

Since only one data base was used in the formulation, the resulting values for the corrected variables are exactly equal to those of the actuals and this does not need further elaboration. Inclusion of additional test localities from the Maritime environment would increase the confidence we could place in the correction equation and this should probably be done in the future. At present, however, this single sample formula should be used to project densities in this stratum.

Table 51. Summary statistics for actual and corrected predicted site occurrence variables, Interior tests.

	SITEdA	SITEdPc	SITE.2A	SITE.2Pc
Interior 1	0.144_0.093	0.163_0.005	0.673_0.857	0.607_0.072
Interior 2	0.199_0.124	0.183_0.031	0.571_0.867	0.636_0.203
Interior 3	0.113_0.087	0.172_0.031	0.879_0.995	0.697_0.152

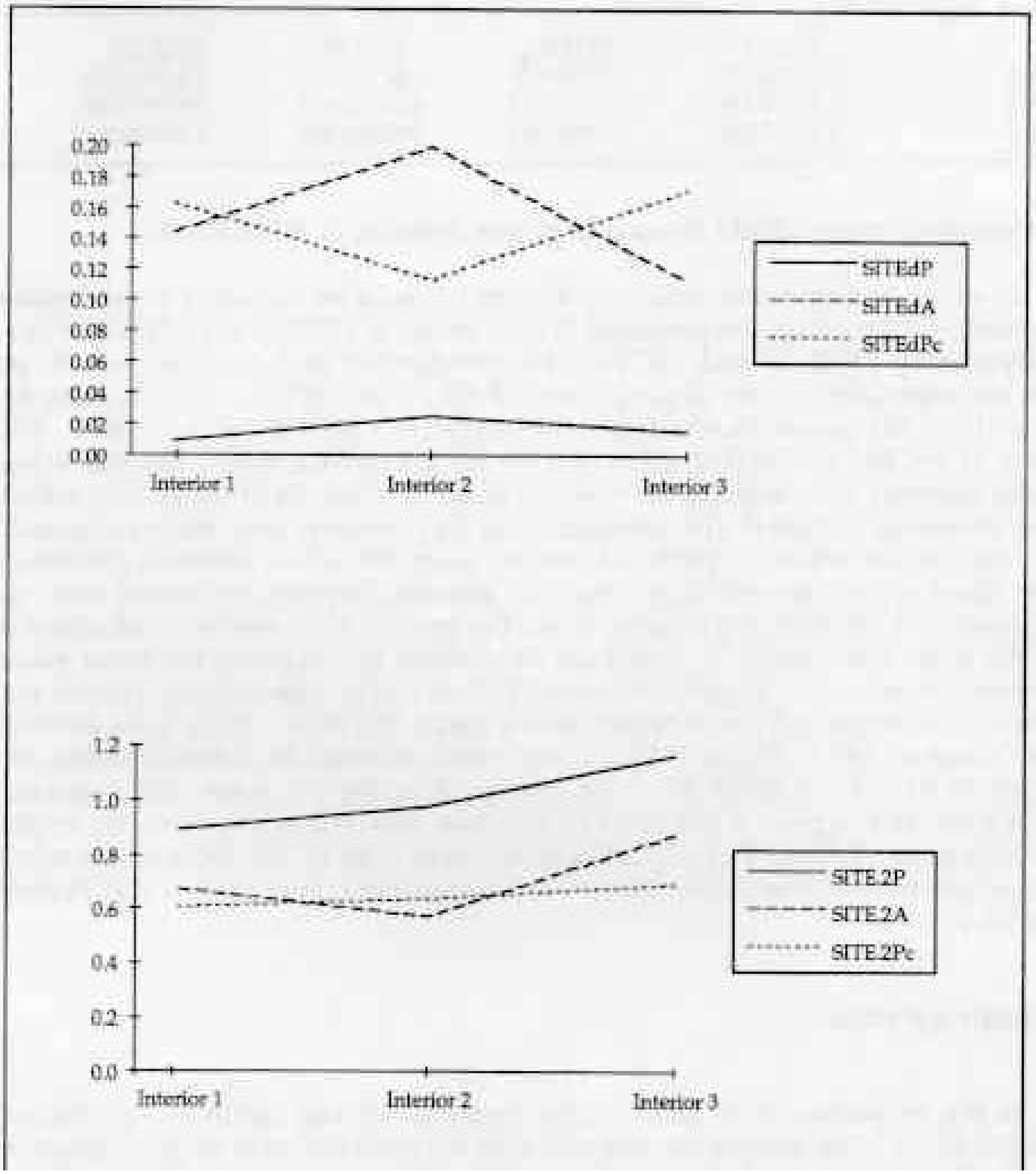

Figure 44. Comparisons of predicted corrected and actual site means

In order to derive true density estimates it would be necessary to undertake the following steps. First, the predicted LOG10 values of LSITE.2 and LSITEd, which are respectively LSITE.2P and LSITEdP, are transformed back into real values, or values corresponding to the original scales of SITE.2 and SITEd. This is done by raising 10 to the power of the individual value of LSITE.2P or LSITEdP. For instance, if we had an LSITE.2 value of 0.477 for a particular point, the real value could be obtained by calculating $10^{0.477}$, which equals 3. Once all of the LOG10 values for the predicted variables are transformed in this manner, they are transformed again into the new corrected predicted variable using one of the formulae presented above. Since we are interested in actual site density, however, we would want to focus directly on the SITE.2Pc variable. Once the mean of this variable is calculated a predicted mean site density for a tract can be obtained by refiguring the mean value by density per acre. The original variable SITE.2, it will be remembered, reflects the density of sites within a 0.2 mile radius, which equals 25.6 acres. Thus, if we derived a mean value of .607 _ .072 for SITE.2Pc, we would calculate an estimated mean for the tract of 0.0237 _ 0.00281 sites per acre by dividing the mean and standard deviation by 25.6 acres. If the tract in question was 470 acres, then, we could reasonably expect to find 11.14 _ 1.32 archaeological sites in this locality. In other words, at a 95 percent level of confidence we can expect to find between 8 and 14 sites on the tract.

Concluding Remarks

In this chapter we have presented the methodology and results of a predictive modelling effort. The method used to construct the models was multiple regression analysis. We also tested the effectiveness of the models against independent data bases from surveys not included in the formulation of the models. Testing revealed that all of the models were quite successful in discriminating locations of low site occurrence from other locations. The models were less successful at differentiating medium from high occurrence areas. However, the LSITE.2 equations effectively distinguished these occurrence zones in three of five tests. The other two tests showed no difference. This would suggest that, over the long run, the LSITE.2 equations will provide the greatest degree of discrimination and accuracy as a basis for predicting site location in the Charleston Harbor watershed. In addition, we were able to design a method for predicting actual site densities. Besides presenting a review of the procedure for applying the models, the final chapter will discuss some other ramifications, including larger regional patterns of site distribution that are not easily understood from the minute scale of analysis that we have been concerned with in this chapter. This information will also be of use in conserving and developing the Charleston Harbor watershed.

VIII. Review and Conclusions

This final chapter will briefly review and discuss the ramifications of the predictive models we have generated as a consequence of this study. The descriptions and evaluations presented in the preceding chapters have all been of a highly technical nature, as is necessary when dealing with such a complex and involved problem. Here, we will forego most of the jargon and statistical methodology laid out as a proof of the effectiveness of the models so that we can provide planners and other interested individuals with an easily understood application guide. Before we do this, however, we will briefly discuss some of the broader regional patterns of archaeological site distribution in the Charleston Harbor watershed that are of general interest to development concerns.

Regional Patterns

Throughout this report we have focused on a very fine scale of archaeological site locational patterning. Under such miopic circumstances it is easy to loose an appreciation for the larger and more obvious patterns of site location that are of equal importance in planning development and devising strategies of conservation. In the initial stages of our research we gathered a set of regional data that have very important ramifications for understanding site locational variability in the Charleston Harbor watershed.

As part of our overall evaluation of survey coverage we calculated the actual area surveyed for all of the modern surveys prior to a cut-off point during the year 1994 in the larger project area. This sample was comprised of the Hugo-Salvage Surveys on the Francis Marion National Forest (Williams et al. 1992a, 1992b, 1992c, 1993a, 1993b, 1993c), a series of 19 other large surveys of privately developed property around the coastal fringe of the City of Charleston and additional Forest Service surveys. The latter included the Sewee Fire Tract (Gardner 1992), 2,012 acres in Wambaw District (Wheaton 1990), and the Salt Pond-South Tibwin (Cable et al. 1995) surveys. The private development tracts included Brickyard Plantation (Espenshade and Grunden 1989), Charleston National Golf Course (Brockington et al. 1987), Dewees Island (Espenshade et al. 1987), Harbor Watch (Judge and Drucker 1989), Hibri Plantation (Eubanks and Bailey 1993), Hobcaw Plantation (Brockington (1987), Jenkins Point (Poplin 1989a), Kiawah Island (Trinkley 1991), Long Point (Adams et al. 1991), Molasses Creek Plantation (Martin et al. 1987), Palmetto Fort (Espenshade and Poplin (1988), Parker Island (Southerlin et al. 1988), Rhett's Bluff (Poplin 1989b), Seaside Farms (Adams and Trinkley 1993), Sunset Point (Drucker and Jackson 1988), and Tea Farm (Adams and Trinkley 1991). Many of these were later used in our modelling effort in one context or another.

The total area surveyed in this sample amounts to about 46,986 acres, which equals a somewhat astonishing 3.41 percent of the combined areas of Charleston and Berkeley counties. Granted, a large proportion of this figure belongs to the Francis Marion National Forest, but private developers have been responsible for surveying nearly 7,700 acres on their own. There are some biases evident in the sample. The most obvious is that the entire inland portion derives from the Francis Marion National Forest, predominantly in Berkeley County. On the other hand, the private developer surveys are predictably concentrated on the coast, or just inland from it. When we look at the distribution of surveys along the coast, though there is a relatively continuous representation from McClellanville, SC to Kiawah Island. The only coastal void within the greater Charleston Harbor watershed is located in the Wadmalaw-Johns Island vicinity and portions of Edisto Island. The primary void in the sample includes the inland tracts of Charleston and Dorchester counties.

The consistent and systematic site discovery methodology employed in these surveys makes it possible to begin to estimate archaeological site density in the larger project area. Although this could be approached using simple site counts as we have done above, this would be misleading for planning purposes because it does not reflect variation in site size. Obviously the size of sites is a much more accurate indicator of archaeological sensitivity. Table 52 summarizes the site area density values for the six large survey areas of the Hugo-Salvage project and the private developer tracts, which are combined for this comparison into a single unit of analysis. This information is broken down in Appendix L at the back of this report for those who would like more detailed information on individual tracts.

Table 52. Site area data for grouped survey locations from modern surveys in Charleston and Berkeley counties.

Group	Mean	Standard Deviation
Bethera	2.89	_ 5.64
Cainhoy	1.33	_ 3.18
Coastal	3.93	_ 5.57
Huger	1.32	_ 1.92
Santee	2.62	_ 3.83
St Stephens	2.10	_ 2.35
Private Tracts	5.94	_ 8.35

The mean values in the table are expressed as percentages of acreage containing archaeological sites. What we see here is that mean site densities range from lows of about 1 to 2 percent of the area in upland tracts such as Cainhoy and St.Stephens to nearly 4 to 6 percent of the area in coastal locations (ie. Coastal Group and Private Tracts). The standard deviations increase with increased site acreage also, which indicates that there is a greater disparity of site sizes in the coastal and intermediate areas such as the Santee and Bethera Groups. In other words, higher means appear to be the result of a greater proportion of larger sites. Some of the coastal tracts, in fact, are characterized by site area densities upwards of 15 to 20 percent of the landscape. The larger mean of the Private Tracts group compared with the Coastal Group from the Francis Marion Forest may also suggest that site area density increases towards Charleston, a somewhat predictable outcome.

Viewing these density patterns on a geographic scale provides us with good evidence that the larger sites have clustered distributions. Figure 45 shows the individual site area densities for all of the surveyed timber stands represented in the Francis Marion surveys. The darker shaded stands represent the greatest densities. In general the highest site area densities occur in association with streams and other kinds of hydric features (ie. salt marsh, swamps, etc.) This is not completely illustrated by the figure as the vast swamp formations in the center of the Forest are not shown. What can be discerned, however, is that the central swamp area contains very few sites, but sites are aggregated around the perimeter of these swamps and bays, generally next to creek heads and streams. Moreover, there is a linear orientation to the site density distributions, which are aligned in a northeast-southwest direction. These alignments correspond almost one-to-one with the underlying geological structure of the region, which consists of northeast-southwest oriented coastal terraces. These terraces were well drained due to their superior elevation and provided important transportation routes and settlement zones for both the prehistoric and historic inhabitants. In general, the greatest site area densities occur on these terrace formations in close proximity to hydric features, a pattern that we recognized at the minute scale we used for predictive modelling, but could not relate to geographic patterning at this larger scale of resolution.

This pattern would be clearly manifest if we could be afforded the opportunity to apply the models to a much larger sample of the watershed, but this would require a great deal of additional expense. Approximately two labor days are necessary to generate an occurrence map of an area equal to the size of one of the test tracts we presented in the last chapter. This includes the time necessary to scan and save the various layers of the CAD base map, to record the variables, to enter the analysis results into a spreadsheet, to calculate the predicted dependent variable, to contour map the predicted values, and to produce a final map of occurrence isotherms. Once a GIS data base has been established for the watershed it would be possible to adapt the model to this more powerful framework and produce a basin-wide map that would be detailed and cost-effective. At present we will have to limit the application to specific tracts of interest. Below we will present a brief summary of the steps needed to apply the model to individual tracts.

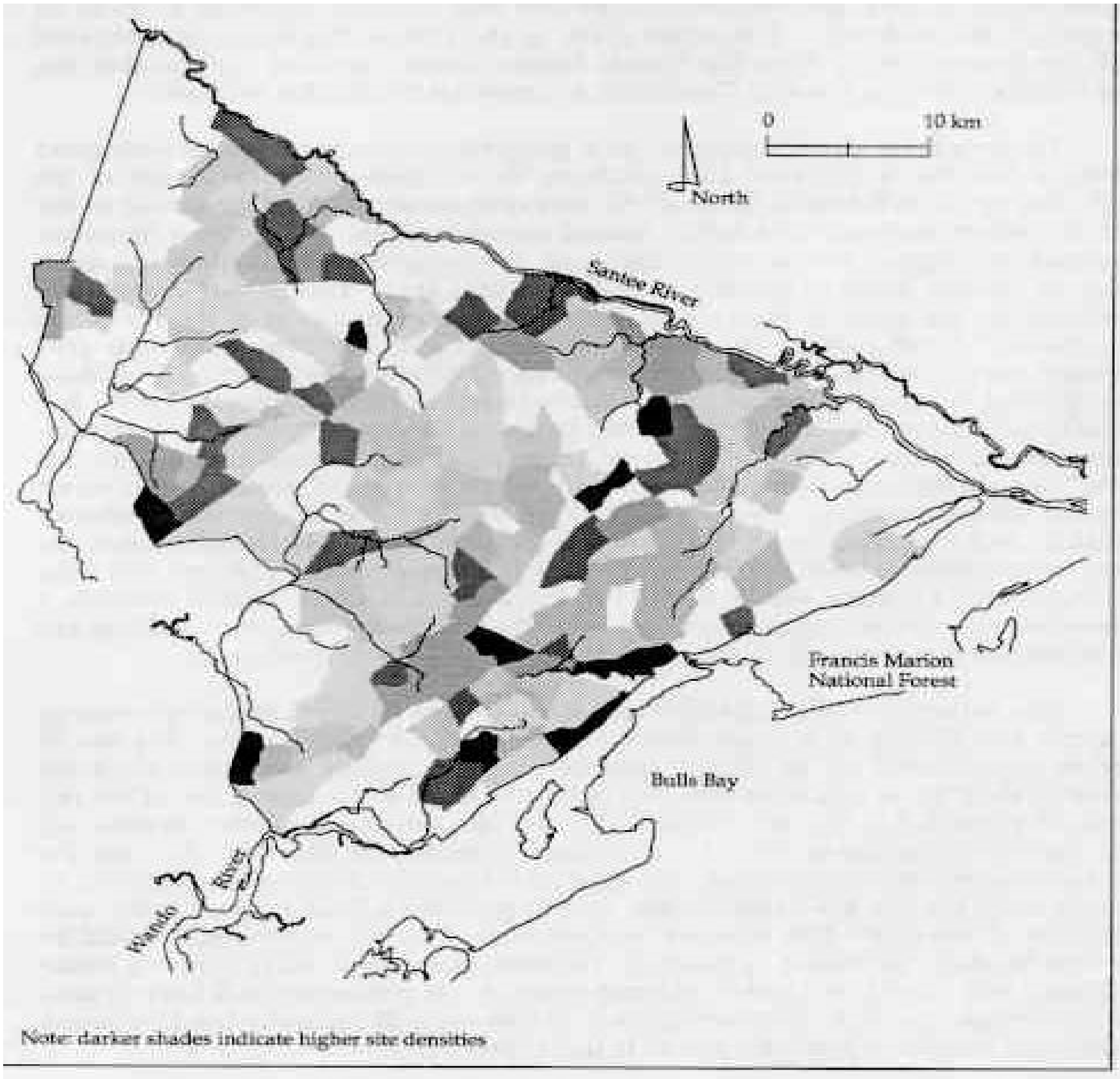

Figure 45. Site area densities by compartment, Francis Marion National Forest

Overview of the Models

The models of archaeological site location developed herein are equations. The method we used to generate the equations is a multivariate statistical technique called multiple regression. Multiple regression attempts to measure the success of a specified set of variables that we referred to as predictor variables, in the prediction of a dependent variable. We identified two independent variables that we were interested in predicting, distance to nearest archaeological site (SITEd) and site density within a 0.2 mile radius of a control point (SITE.2). Because the predictor variables were of different scales and their distributional relationships were not wholly linear we transformed the variables into LOG10 values in preparation for generating the best-fit multiple regression equations. Consequently, the dependent variables were discussed in terms of LOG10 values (LSITEd and LSITE.2) throughout most of the analysis. Best-fit models were generated for two different environments, the Interior and the coastal fringe, which we referred to as the Maritime environment. This was done because the variables we chose to measure were structured differently in the two environments.

The independent variables used in the model consisted of a subset of a more inclusive grouping of soil and stream characteristics. We found that for the Interior Sample the diversity of soil patches surrounding a control point (LHx), distance to soils of drainage ranks 4 (LDR4) and 1 or 2 (LDR1/2), distance to nearest soil interface, and distance to nearest stream (LSTd) were most instrumental in predicting the occurrence of archaeological sites, while LHx, LSTd, soil patch diversity within .05 miles of a control point (LH.05), distance to salt marsh (LDR6), distance to soils of drainage rank 1 (LDR1), and associated soil drainage rank (LDR0) were most effective in predicting sites in the Maritime Sample. Note that all of these variables have the prefix L, which means that the LOG10 transformations of each were used to generate the models.

The best-fit models explained about 50 percent of the variability in the dependent variables. This indicates that there is a good deal of variation related to site location that is left unexplained, but subsequent testing revealed that applications of the models to known survey tracts were successful in differentiating areas of high and medium site density from areas of low site density. They were not as successful in differentiating medium and high occurrence zones, but we found that the equations using LSITE.2 were more successful in this regard than those using LSITEd. Based on our tests, we can expect the LSITE.2 equations to effectively differentiate medium from high occurrence zones about 60 percent of the time. For this reason we recommend that planners and others interested in applying the models use the LSITE.2 equations for the two environments. These equations are presented here again for ease of reference:

(1) INTERIOR ZONE

LSITE.2 = -0.947954 + (-0.116274 x LSTd) + (0.852889 x LHx) + (0.090858 x LDR4) + (-0.19172 x LDR1/2) + (-0.132135 x LNEAR).

(2) MARITIME ZONE

LSITE.2 = -1.26294 + (-0.199682 x LSTd) + (3.51543 x LHx) + (-0.508256 x LH.05) + (-0.185025 x LDR6) + (0.22531 x LDR1) + (-0.972209 x LDR0).

The relative site occurrence value for any point in the Charleston Harbor watershed can be predicted using one of these equations. This is done simply by measuring the variables we have described for a point and then summing the constant, the first value in each formula, and the products of the transformed variables and their appropriate coefficients.

The method of application of the models is the same one we used in the various test cases. The appropriate section of the SCS soil maps are scanned and transferred to a CAD file. Then the boundaries of the development tract are rescaled and overlaid on the soil map within the CAD file. Next a grid of measurement points spaced at 0.1 mile intervals is overlaid on the soil and tract boundary layers. It is advisable to extend the grid a good distance beyond the tract so that the skewing that occurs in contouring algorithms at the fringes of the map data will not be manifest within the tract itself. The independent variables are then measured and recorded at each grid node as described in Chapter V and these data are entered onto a spread sheet file. Once the spread sheet is completed, it is a simple matter to calculate the predicted values of LSITE.2 for each node or control point using the multiple regression equation presented above. These values can then be imported into a contouring program, we used the MACGRIDZO program here, where site occurrence contours are mapped. These contour maps can then be imported into the CAD file where they can be layered into the base map to demarcate the precise locations of the site occurrence isotherms within the development tract.

The difference between occurrence isotherms and probability zones was discussed earlier and will be reiterated here. Since contouring algorithms were used to map the predicted dependent variable values, the resulting isotherms represent arbitrary boundaries in a continuous array of points across the landscape. These isotherms are ranked in accordance with their relative value in predicting site location according to the models, but they do not represent probability zones *per se*. Probability zones, as commonly formulated, represent polygons that contain the same probability of occurrence throughout. The probability of finding a site at one location within the zone is the same as any other location within the zone. In our application, the probability of occurrence fluctuates from one location to the next within each isotherm. Within any isotherm band, the locations closer to the next highest ranking isotherm have higher probabilities of site occurrence than locations nearer the next lower isotherm. Moreover, the data from the equations do not reflect explicit probabilities of site occurrence, only relative ones. Thus, we cannot say precisely what the probability of finding a site at any specific location will be, only that the location has a high or low ranking for site occurrence relative to other locations in the vicinity.

Through a series of adjustments and additional calculations we also showed that the models can be adapted for the purpose of estimating mean site densities. It is important to note that these estimates apply to an entire tract, since the correspondence of predicted and actual values is not great at the base level of control points. In order to calculate mean site densities it is first necessary to transform LSITE.2P back into a non-logarithm value. Once this is done a corrected predicted value for each point can be calculated using the following simple regression equation: SITE.2Pc = .408 + (.264 x SITE.2P). Mean site density per acre can then be calculated by converting the mean of SITE.2Pc from a 0.2 mile radius area (25.6 acres) into per unit acre by dividing the mean and standard deviation by 25.6. The expected number of sites for a tract can then be found by multiplying this adjusted mean and standard deviation by the amount of acreage in the tract.

Final Remarks

The predictive models discussed in this report represent tentative exploratory efforts. They explain a great deal of variation in archaeological site location in the Charleston Harbor watershed, but they leave a great deal left to explain as well. It is probable that we will not achieve a significant advance in our understanding of site location until we consider the effects of altogether new variables or newly formatted variables. We may also find that we are approaching the maximum level of resolution and we may not achieve greater clarity of patterning until we partition the universe of sites into smaller, more homogeneous groupings such as culture historic period or site functional type. Whatever the case, it should be appreciated that this effort represents a beginning for predictive modeling in the Charleston Harbor watershed, not an end in itself.

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Appendix A

Listing of Stage I Projects

For copies of these appendices, please contact the SC-DHEC Office of Ocean & Coastal Management, 1362 McMillan Avenue, Suite 400, Charleston, SC 29405.

Appendix B

Frequency of Culture Historic Components
for
Stage I Projects

For copies of these appendices, please contact the SC-DHEC Office of Ocean & Coastal Management, 1362 McMillan Avenue, Suite 400, Charleston, SC 29405.

Appendix C

Interior Sample Data Base

Stage II

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Appendix D

Maritime Sample Data Base

Stage II

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Appendix E

Interior Test 1 Data Base

Stage II

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Appendix F

Interior Test 2 Data Base

Stage II

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Appendix G

Interior Test 3 Data Base

Stage II

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Appendix H

Maritime Test 1 Data Base

Stage II

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Appendix I

Maritime Test 2 Data Base

Stage II

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Appendix J

Site Density Data Base, Interior Tests

Stage II

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Appendix K

Site Density Data Base Maritime Tests

Stage II

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Appendix L

Site Area Density Data for Projects in Berkeley and Charleston Counties

Stage I

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